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The Chemical Industry in 1938

THE year that is drawing to its close has been one of the most difficult periods that industry has ever experienced. From the early spring the general atmosphere of tension and uncertainty, with its bad effects on business confidence, increased until, by the end of September, the nation was brought to the brink of a chasm which would have plunged it into the chaos of war. No one is likely to forget how the tragedy was successfully averted at the last moment, least of all the industrialist who stood to lose immediately all his normal operating conditions. It is a tribute to the calm and dogged determination of the business community that the effect of the crisis upon trade was of such short duration. Almost within a week of the conclusion of the Munich Agreement business was again running a course closely resembling the normal and from then until the close of the year confidence, so essential to the full development of industrial activity, has steadily grown. In addition to these wholly abnormal circumstances, the exporter during the past year has had to contend with many adverse factors such as high tariffs, quotas and, notably in the case of Germany, State-aided foreign industries. Last month's Anglo-American agreement was the successful outcome of trade negotiations with a country of notably high tariff rates and, even if the concessions obtained on the products of the chemical industry do not appear to be very substantial, the concessions made by both countries on all the many different classes of goods are bound to lead to a great increase in transatlantic trade which cannot but be, in the long run, of far-reaching benefit to all types of manufacturing industries. Preliminary trade negotiations on a similar basis have also been begun with Germany and, although here the problem of arriving at mutually acceptable terms will be far more difficult, it is not too much to hope that a satisfactory solution will eventually be found. In any event these are definite indications of the favourable attitude of the Government towards the removal of obstacles in the way of a more prolific international trade by personal negotiation between the parties concerned.

It can be said broadly that trade in general during 1938 receded over that of the previous year but was slightly better than in 1936; while the chemical industry fared better than most industries. Total imports of raw materials in the first eleven months of 1938 showed a decrease of £60,303,683 compared with the same period of 1937, and an increase of £5,747,586 compared with 1936. These interesting figures provide some information on the quantities of chemicals used, as many of these raw materials require chemical treatment in processing and manufacture into saleable articles. Both imports and exports of chemicals, drugs, dyes and colours decreased in the first eleven months of this year compared with 1937, thus, imports fell by £368,221, and exports by £2,404,946; but here again comparison with 1936 shows an improved position, imports being up by £856,484, and exports by £1,248,590. Imports of heavy chemicals were negligible in comparison with exports, although there was a considerable reduction in the latter business. For example, exports of bleaching powder fell in value from £186,544 to £144,993; sodium carbonate, including soda crystals, soda-ash and bicarbonate from £940,698 to £813,579; and caustic soda from £1,050,262 to £977,638 in the first eleven months of 1938. Over the same period of comparison, imports of finished dyestuffs from coal tar rose in value by £34,235, while dyestuff exports fell by £331,849; imports of calcium carbide fell by £46,574; imports of superphosphate of lime fell by £14,222 and other manufactured fertilisers by £8,096; and exports of ammonium sulphate rose by £129,380.

Consumption of lime and basic slag during the year was greatly stimulated by the subsidies provided by the Government Land Fertility Scheme on these fertilisers. These subsidies have now had a lengthy period of operation and have proved themselves to be of great value to the farmer who, judging by the number of applications made under the scheme, appreciates the opportunities provided. This is of particular interest at a time when the defences of the country, including the vital question of food supplies, have been subjected to the closest examination. Although certain essential food commodities have been stored against an emergency, the view that home production of foodstuffs should, at the same time, be encouraged as far as possible, has become more generally accepted. While the output of home-grown crops has increased in certain cases, the fact remains that the total area of land under cultivation is decreasing. Many representations have been made to the Government recently on this

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matter; these may result in an extension of the scheme to include subsidies on the other commonly-used fertilisers. Not only would this encourage agriculture, but it would remove the present unfair discrimination for two types of fertiliser only. Another event of interest to the fertiliser industry was the holding of the first international fertiliser congress. It took place in Rome in October and was attended by delegates representative of 48 countries.

As mentioned above, imports of calcium carbide in January to November this year fell in value by £46,574, compared with the first eleven months of 1937. But the quantities imported during the corresponding period of the last three years show a regular increase, thus they were: 1,011,304 cwt. in 1936; 1,153,730 in 1937; and 1,201,631 in 1938. This adds point to the rejection of the Caledonian Power Bill in Parliament early this year. It will be recalled that a major proposal of the Bill was the erection of a calcium carbide works by the British Oxygen Co. at Corpach, near Inverness. Electric power was to be provided by a hydro-electric plant on Loch Quoich. The scheme was rejected mainly because it was considered that the plant would damage the natural beauty of the district and that water at present used for carrying away the sewage of the town of Inverness would be diverted. This rejection on seemingly flimsy grounds not only negatived a scheme which would render the country self-supporting in an important industrial raw material at present wholly imported from abroad, and which would bring industry into a depressed area, but it had a further unfortunate result. The British Oxygen Co. had also planned to manufacture carbide in South Wales, where coal would be used for the generation of the necessary electric power. As the cost of generating the power from coal is higher than by hydro-electric plant, it was intended that the Corpach plant should subsidise the Welsh plant; both were inter-connected integral parts of the plan. Following the rejection of the Corpach Scheme, the announcement in August of the abandonment of the South Wales project was not therefore unexpected; it was nevertheless disappointing. The rejection of a proposition of such national importance on considerations of interference with natural beauty and with a town's sewage disposal (for which an alternative method could surely be found) must strike the most casual observer as incongruous.

The publication of the report of the Falmouth Committee on the home production of oil from coal had been eagerly awaited and the report itself caused a great deal of interest owing to its bearing on the problem of national defence. The report, however, made no recommendations substantially altering the position of the home oil industry. In brief, the Committee came to the conclusion that a policy of depending on imported supplies with adequate storage was the most reliable and economical means of providing for an emergency. It was considered that the future development, or even maintenance at the present level, of the oil from coal industry depended upon the continuance of a guaranteed preference on home-produced spirit. They, therefore, recommended a guaranteed preference of 8d. per gallon on home-produced spirit and diesel oil, the preference to be in force until 1950. The preference offers support for the establishment of synthetic oil undertakings, and the Committee hoped that a large scale Fischer plant might be erected. So far this hope has not been fulfilled.

The chemical industry was seriously concerned in the middle of the year by an inquiry into proposals empowering the Potato Marketing Board to manufacture chemical products from potatoes. The proposals would obviously extend the activities of the Board far beyond the purposes for which it was originally created and would mean in effect that the chemical manufacturer would have to face competition in his business from a State-aided organisation. The Minister of Agriculture announced this month that the report of the Commissioner conducting the inquiry had been received, but that it was not possible to say when it would be laid before the House. Publication of the report is now a matter of time and it can only be hoped that when it appears it will not constitute a precedent for the Milk Marketing Board to seek powers to enable it to compete with the plastics and textile industries by manufacturing casein plastics and artificial wool from milk. This may sound a ludicrous supposition, but it is a logical corollary to the Potato Marketing Board making alcohols, solvents and synthetic resins from potatoes.

Turning now to the British Industries Fair which shows something of the new developments going on in the industry, this year's fair again provided an interesting range of new products. Prominent among these were highly purified sodium alginate, *o*-indolyl acetic acid for promotion of plant growth, a new series of ionones for perfumery, a new glass-clear thermoplastic and several new oxidation-reduction indicators. *O*-Anisidine and *o*- and *p*-phenetidene were displayed for the first time, as well as caffeine derivatives, alkaloidal camphorsulphonates, iodo-organic acid derivatives, and nicotinic acid. The Empire Exhibition at Glasgow, while not, of course, being concerned so much with matters of direct trade interest, was a remarkable achievement from the spectacular point of view and was very well worth a visit. The Society of Chemical Industry's meeting at Glasgow, supplementary to its annual meeting held in Canada, provided an excellent opportunity of seeing the exhibition under expert guidance. Mention must also be made of the interesting symposium on the trend of progress which was held during the Glasgow meeting and to which contributions were made by the different groups. Among the many papers read during the year at meetings of the chemical bodies published in technical journals (a proportion of which is referred to in articles in this issue), two conferences should be referred to. The first was a conference organised in June by the Institute of Petroleum to discuss oil shales and cannels. A series of noteworthy papers on the technical aspects of the subject were presented but it was perhaps a pity that the economic side of the shale oil industry was not considered. The second was an international rubber technology conference held under the auspices of the Institution of the Rubber Industry. Over one hundred papers were presented covering almost every phase of rubber technology from the tree to the finished goods, and including a number of contributions on the synthetic rubbers. Of the legislative measures put into force during 1938, the new Factories Act consolidated and amended regulations previously contained in a large number of Acts. The new Act made no startling requirements as regards the chemical industry, which has always been progressive in adopting safety measures quite voluntarily on its own account. New Acts relating to trade marks and patents also came into operation during the year.

A Message from the President of the Society of Chemical Industry

I APPRECIATE very much the opportunity given me as President of the Society of Chemical Industry, to extend to your readers on behalf of the Society greetings and best wishes for the New Year. I believe this is the first time a Canadian President of the Society has had such an opportunity.

This year has been outstanding in the history of the Society in many ways. In the first place the Annual General Meeting of the Society was held in Ottawa, Canada, in June last, followed by a tour of some of the principal industrial centres of Eastern Canada, and secondly a special Autumn Meeting was held in Glasgow in order to permit the Society to participate in the Empire Exhibition there. This latter meeting was also in the nature of an annual general meeting, which was very well organised and well supported.



Mr. Victor G. Bartram, President of the Society of Chemical Industry.

I am convinced that as a result of the Canadian meeting and the industries and cities visited, our overseas visitors particularly must have been impressed with the wonderful resources we have available in Canada. In these troubled times one cannot help but evaluate the great potential chemical, metallurgical and hydro electrical possibilities of Canada from an Empire defence and development point of view. I am convinced, therefore, that many of the prominent British scientists, and industrialists, who made this trip must have returned home impressed with the marvellous possibilities available here even for peace time purposes and must fully realise the untold possibilities Canada offers in time of national emergency. Coupled with our natural resources, in spite of what some politicians may say, Canada is thoroughly Empire-minded and British to the core.

The meetings in Canada were attended by representatives from several continental countries and by a large delegation of the Society's members from the United States. I feel certain that the good fellowship developed at our meetings and during the tour will result in furthering the interest of the chemical industry as a whole as well as the interests of the Society.

From this distance from the seat of operations in London, I can only judge the state of affairs of the Society from reports received and from the minutes of the meetings of the Council and various committees who handle the Society's affairs. On this basis I feel that the membership of the Society is more active than ever, and as any Society is judged by the efforts of its members, this I believe augurs well for our future. I, therefore, want to take this opportunity to congratulate the present Council for the able way in which they are conducting the Society's affairs. I also want to express my indebtedness to Lord Leverhulme, who is acting as my deputy owing to the impossibility of my being able to preside over the affairs of the Society during the conduct of its everyday business. I am sure every member will join me in expressing thanks to Lord Leverhulme for again devoting so much of his valuable time to the affairs of the Society.

I believe the Society's foreign relationships are more cordial than ever, as was made clear during the International Congress of Pure and Applied Chemistry in Rome last May. The Society should be justly proud of the interest aroused at the Rome meeting in connection with its publications.

During the past year the Society has maintained its outstanding record of achievement, built up over the past fifty-eight years and I feel certain all of your readers will willingly admit the service the Society has been able to render towards the advancement of the chemical industry during this period.

I wish to thank you for this opportunity to greet your readers and extend to you and your publication my best wishes for your continued success.

VICTOR G. BARTRAM.

1938—Retrospect and Futurity

By

E. F. ARMSTRONG, Ph.D., LL.D., F.R.S.

THIS is a moment to take stock in the chemical industry—as well as nationally. At no time has it, perhaps, been more necessary to envisage and meet new conditions. The barriers to the British chemical trade are numerous; the United States has high tariffs (although concessions have recently been made on some products through the Anglo-American trade agreement), in Germany there is virtual prohibition of imports. Yet both countries send freely to our market at prices which often bear no proper relation to those charged in their home markets.

The chemical industry is accustomed to commend members of the civil services for their assistance in matters of detail, but this does not make up for the neglect by the Government in matters of policy. Foreign policy must go hand in hand with industrial policy; only by being strong and prosperous can our industries bring contentment to the people and prosperity to the State. For the future, with a policy of economic self-sufficiency developing in so many lands, we must look more and more to the Empire for business. Britain should have the whole of the Empire trade, but it must also deserve it. The needs of the Empire must be studied through personal contacts and their demands met; they differ from those made at home. The smallness of the individual Empire markets causes a difficulty which will persist for some time even if a more vigorous emigration policy is adopted. The home chemical industry may have to consider some collective approach to this problem by a system of joint selling; this has been advocated by me before and there has been no reason since to make me change my views.

The last year or so has seen a continuance in Germany of the collective efforts to attain self-sufficiency by substituting synthetic materials for natural imported products. Many of these are no doubt uneconomic financially but it is a mistake to underestimate the importance and the success of the movement.

In America the urge to make new synthetic organic pro-

ducts and to find applications for them continues at an accelerated tempo. The possibilities of petroleum as a raw material for chemical synthesis are being more and more realised.

We are unaware of parallel developments to these in England on anything like the same scale, though there is much valuable work going on in many directions. Priority has perhaps been given to work on chemicals essential for rearmament about which reticence must necessarily be observed. It is believed that the country is better prepared against eventualities in the chemical than in most other directions.

In the financial sense, judging by the published reports, the British chemical industry has done reasonably well during the past year whereas in America the financial results have been much less satisfactory. In Germany industries are no longer on a comparable economic basis. The Board of Trade figures quoted in Mr. E. V. Evans' address as chairman of the Association of British Chemical Manufacturers support the view that the chemical industry is holding its own better than industry in general. Exports of chemicals are higher and imports lower in 1938 than in 1936; there has been some recession compared with 1937.

It is difficult to select any particular achievements of the British industry for comment largely because it is not the practice to broadcast these to the public to the extent which this is done in Germany and America. In the field of distribution, for example, there are two remarkable achievements to chronicle: they are the purification of a vitamin by distillation in a very high vacuum and the manufacture of nearly 100 per cent. pure zinc by distillation in continuous apparatus resembling that used in the oil industry. Both these processes are in operation as normal manufacturing work.

In these days of broadcasting news by Press, radio and cinema no industry can afford to neglect the public, and it is its task to make both official and public opinion so well acquainted with its structure and achievements that there is an understanding of its value and its problems.



Dr. E. F. Armstrong, F.R.S.

It is not enough for chemists to know the vital importance of their profession and their industry and themselves for the prosperity of Britain and for its defence; the facts must continually be brought home to the man-in-the-street, who must be taught that British chemicals should be bought in preference to foreign, that British chemists are the equal of foreigners, and as clever as inventors and patentees, in spite of their having Anglo-Saxon names.

Widely discussed in America this summer, even by the lay public, was the solution of a much desired problem, the production of textile fibres from a synthetic resin. The resin is a thermoplastic polyamide made from hexamethylenediamine and adipic acid and the product is spun from solution into a non-solvent in an atmosphere of nitrogen. The filaments are subsequently improved by cold drawing when they have a good elastic recovery, making the fibre specially suitable for hosiery. A factory is stated to be under construction to make the new threads. When successful it will realise the chemist's dream of making garments from coal; this is indeed an outstanding achievement.

The provision of finance for new inventions is still a vexed question in this country, the more so since the complete working out of any new project to-day demands sums in excess of that which can be provided by small private syndicates. It is a debatable question to what extent firms should take on new inventions knowing full well that only a proportion of them will be successful and that the money will be taken from the legitimate business of the firm.

There is undoubtedly a less independent spirit in the new generation than in the days when a father was still proud to see his sons making their way by their own efforts. The new male generation is on the hunt for civil service positions and the new female generation prefers those who are "entitled to a pension" to those who are carving out an independent existence.

It is becoming increasingly clear that the development of industry, and of the chemical industry in particular, is handicapped by the misuse of the patents, particularly of the so-called omnibus blocking patents. Some amendment of the patent legislation, including the taking out of patents under international convention, is urgently needed. Apparently this country is not alone in holding this view for a prominent German statesman, Dr Rudolf Brinkmann, has recently stated: "Patent law has offered an ever wider field for protective and interlocking patents. This results in the fact that in order to ensure earnings and wealth, possible progress is crippled and the fruits thereof withheld from the nation. Not just the inventor, nor he who has put only his money in a project, but rather the entire nation has an interest in seeing that inventions are made and brought to a practical stage; for the nation as a whole created the cultural, legal and economic basis for research and invention."

As long as the law allows the granting of patents which are intended to keep others out of a promising and largely unexplored field of inquiry the practice will continue, but it must be realised it is becoming increasingly injurious to progress, and to the nation. It is high time the chemical industry and the Federation of British Industries took this matter energetically in hand.

It seems essential that the industry and the profession must be united to face the difficulties which lie ahead. All chemical firms must be members of the A.B.C.M., every chemist should join one or more of the chemical societies, soon, we hope, to be welded together by the Chemical Council. These bodies are bearing the burdens of all and their activities are already checked by lack of funds. The few shillings per head of the annual subscriptions can mean nothing to the individual absentees, but their default deprives Britain of having an organisation which is in every respect first class. If freedom involves liberty to criticise and to do nothing to support a national cause then the principle of freedom is at stake and the free country will fail.

Contrast the attitude here with that across the Atlantic where the American Chemical Society passed the 21,000 membership mark early in 1938 and is growing at the rate of well over 2,000 new members a year (2,868 in 1937). This membership enables the A.C.S. to do much for its members and to exert great influence on their behalf. Perhaps largely in consequence of this success the leadership in matters chemical has to-day passed to the U.S.A.

This article, intended to be a review of 1938, has instead become in the main an indication of future trends. 1938 has been a year of crisis, of awakening, perhaps of realisation that things are not going to be quite the same in the future. The making of this future is in our own hands—if we accept the challenge and act rigorously in a logical and scientific manner the free world is there to conquer and to hold. If we tarry to argue, to discuss and hope to muddle through we shall find others, swifter and more efficient before us.

Conditions in the Heavy Chemical Industry in 1938

By

P. PARRISH, F.I.C., M.I.Chem.E., M.I.Gas E., F.I.I.A.



Mr. P. Parrish.

THE year 1938 has been unique in many ways: not least in the realm of politics. Continually there have been ominous clouds, inordinate demands and disconcerting threats. Emergence from one difficulty has been succeeded almost immediately by another, and there appears at present no end to these nerve-racking episodes. It is evident that everything must be subordinated to rendering our country safe.

While it cannot be doubted that there has been a certain recession of activity in the chemical industry in 1938, as contrasted with 1937, it seems clear that the lower level of 1936 has not been reached.

The chemical industry has suffered[1] from unfair competition arising from the use of such devices as subsidies, special marks and clearing arrangements. It is well-nigh impossible to compete unaided with what are essentially State-forged trade weapons. Appropriate steps should be taken by the British Government with those countries which fail to afford a reasonable measure of trade-reciprocation.

Internally there is need for a co-ordinated policy in the matter of subsidies. The Minister of Agriculture and his colleagues will be confronted with trouble so long as they depend on a "tangle of small devices." The way of escape from these perplexing rural revolts is to call a conference of all the interests involved.

The importance of a flourishing agricultural industry in this country, in which the chemical industry, and particularly the heavy chemical section, would participate, cannot be over-emphasised. Mr. Lloyd George's words of last year are still significant. He remarked: ". . . The front where we nearly broke down in the Great War was the food front: it was food shortage which broke down Germany, Austria, Bulgaria and Russia. It nearly broke us down before they broke down."

The Board of Trade figures for the index of production in the chemical group were 115.4 in 1936, 124.5 in 1937 and approximately 120 for the six months to June 30 of this year.

Progress of the Industry

No one who has studied the speech of Lord McGowan[2] at the eleventh annual meeting of Imperial Chemical Industries, Ltd., can doubt the resiliency of the heavy chemical industry, and the progress that it has made. In 1938 there has been an excellent demand for alkalies, and experimental work on a large scale for the production of activated coke by the addition of sodium carbonate is said to give promise of another substantial outlet for alkali. Satisfactory progress with the establishment of the alkali undertaking at Port Adelaide (Australia) has been made, and the work on the Indian plant is progressing satisfactorily.

It is expected that the production of sulphuric acid in 1938 will be of the order of one million tons, in terms of monohydrate. Contact processes continue to grow in importance. In 1927 some 13 per cent. only of the production of sulphuric acid was manufactured by that process: in 1936 the percentage reached 29.6, and last year 31.2. Sir Robert Horne has pointed out that the production of sulphuric acid this year at the Imperial Smelting Co.'s works, Avonmouth, was 201,259 tons—a slight decline, compared with the peak output of 1937, which reached 202,102 tons of 70 per cent. acid. He further remarked that the cost of producing acid was affected by increases of labour, and by advances in price of essential supplies.

This year two units of contact plant have been erected at one of the Government factories by Cyanamid Products, Ltd., and one unit has been erected by Simon-Carves, Ltd., with Monsanto vanadium catalyst, for F. W. Berk and Co., Ltd. Another unit is in course of erection at Flixborough—the works of Nitrogen Fertilisers, Ltd., a subsidiary of Fison, Packard and Prentice, Ltd., of Ipswich. At this works it is understood that the vanadium catalyst of Dr. Baslini is being adopted.

Synthetic Ammonia

Little has been published during the year concerning any improved technique in the synthesis of ammonia, or indeed about catalysts which might give higher efficiencies.

The technical preparation of pure hydrogen under high pressure by indirect electrolysis of water has been the subject of discussion, and hydrogen generators, yielding 200 cubic metres per hour, are described. The principle is one involving a reaction between caustic soda and ferro-silicon (75 per cent. Si), which proceeds at a suitable temperature with explosive speed, hydrogen being obtained under a pressure of 200 atmospheres in a high state of purity, since impurities such as PH_3 or NH_3 remain in solution. The economics of the process have not been discussed.

G. Fauser has suggested the preparation of nitrogen-hydrogen mixtures from coal under pressure. This process is one involving the preparation of hydrogen from water gas in an apparatus in which air with added oxygen is passed over semi-coke at 700° C. to give hydrogen and nitrogen, with carbon dioxide.

New Synthetic Ammonia Plants

Synthetic ammonia plants for Finland and Mexico have been the subject of consideration during the year, while the State-owned nitrogen works at Diesosgeutmarton (Rumania) has received a Government grant with a view to increasing the capacity of the factory. A contract for the construction of a synthetic ammonia works at Barosevae (Jugoslavia), it is reported, has been entrusted to a German firm. About 8 tons daily of ammonia are to be produced, of which 70 per cent. is required for the home market.

A synthetic ammonia plant employing the Mont-Cenis process and coke oven gas is being erected at Flixborough for National Fertilisers, Ltd. This plant is said to have a capacity of 50,000 tons of sulphate of ammonia per year.

The following figures, culled from the Alkali Reports for the year 1937 by Mr. Damon, are interesting as representing

the quantity of ammonium products manufactured in England and Wales during the three years 1935, 1936 and 1937:

OUTPUT OF AMMONIUM PRODUCTS—ENGLAND AND WALES.

EXPRESSED AS SULPHATE (25¾ PER CENT. NH_3)—TONS.

From liquor produced in:	1935.	1936.	1937.
Gas works	109,200	120,300	122,400
Other works (including coke ovens, iron works, producer-gas, synthetic, etc.) ..	461,700	455,100	535,600
Total	570,900	575,400	658,000

NOTE.—Of the above total, the equivalent of 112,200 tons was manufactured as concentrated liquor and 34,000 tons of this concentrated liquor was subsequently converted to salts, which are included in the 658,000 tons above. The total quantity of salts of ammonia produced, therefore, was 545,800 tons, and the net production of ammonia was 624,000 tons.

Ammonium nitrate is manufactured by the Dutch State Mines (B.P. 474,181) by a process characterised by the fact that the vapour developed by the heat of reaction between ammonia and nitric acid, and in some cases other substances, is introduced into a circulating liquor of ammonium nitrate, or mixtures containing such. Preferably the ammonia and nitric acid are introduced into the circulating liquor at a point where the pressure is such that the liquor does not boil, ebullition occurring only after the reaction has taken place. Preferably the boiling occurs at a pressure below atmospheric.

Fuel and Gas Industries

Taking the world as a whole, solid fuels[3] outweigh in importance the liquid and gaseous fuels. In 1936 more than 175 million tons of solid fuel were produced, whereas the output of petroleum amounted to 247 million tons, and of natural gas 33 billion cubic metres. It is computed that the vast store of coal would last, at the average rate of consumption for the past ten years, for another eight hundred and sixty years. Bound up with the progressive exhaustion of our coal resources are the ever-increasing difficulty and cost of mining.

The report of the Falmouth Committee, published in February last, on the coal oils industry, was a comprehensive document, but the main findings and conclusions of the Committee had apparently largely been anticipated by those directly concerned in coal oils production. The following figures, culled from that report, are extraordinarily interesting, as representing the production of crude benzole during the three years 1934, 1935 and 1936, and the output of refined products therefrom. The evidence received by the Falmouth Committee indicates that the creosote fraction of high temperature tar, which amounts to about 40 per cent. of that tar, is equally, if not more, suitable than low temperature tar for the hydrogenation process. The figures of creosote production and trade, given below, merit record here.

PRODUCTION OF CRUDE BENZOLE DURING THE PAST THREE YEARS.

	1934.	1935.	1936.
		Million Tons.	
Total quantity of coal carbonised at gas works and coke ovens	34.8	35.5	39.1
		Thousand Gallons.	
Crude benzole produced:			
By gas stripping at gas works	13,590	17,260	20,160
By gas stripping at coke ovens	48,130	51,570	58,910
By distillation of tar ..	3,400	3,500	3,900
Total	65,120	72,330	82,970
Refined products:			
Motor spirit	39,270	44,573	51,190
90's benzole	2,165	1,957	2,179
90's toluol	1,133	1,523	1,663
Pure benzole	2,292	2,210	2,652
Pure toluol	1,330	1,550	1,743
Xylol, naphthas, etc. ..	3,164	5,257	5,290
Total	49,354	57,070	64,717

CREOSOTE PRODUCTION AND TRADE.

Year	Production.	Exports (Million Gallons).	Home Consumption.
1931	63	13.2	49.8
1932	55	13.0	42.0
1933	65	15.8	49.2
1934	70	20.3	49.7
1935	70	22.2	47.8
1936	80	32.0	48.0
1937 (provisional)	90	33.5	56.5

The production of tar at gas works and coke ovens amounted, in 1936, to 388 million gallons, or an average of about 10 gallons per ton of coal carbonised.

The Institution of Gas Engineers, in conjunction with the University of Leeds and the Fuel Research Station, are investigating processes directed to the production of cheaper coal gas. Virtually, there are at present two processes under consideration. One involves complete gasification of coal under pressure, using oxygen and steam. This process is likely to yield about 275 therms of 350 B.Th.U./cu. ft. gas, which can be increased to 500 B.Th.U./cu. ft. gas by the removal of CO_2 under pressure with water. This gas can, if necessary, be subsequently "up-graded" by passage over a catalyst, converting the carbon monoxide and hydrogen to methane.

The other process contemplates the treatment of coal with hydrogen under pressure at temperatures from 500° to 600° C. This method gives a yield of 300 therms per ton of coal treated, the gas having a calorific value of 500 to 600 B.Th.U/cu. ft. A light tar, semi-coke of high reactivity, and ammonia in concentrated form can be anticipated from this process. By working at a temperature of, say, 800° to 900° C., it is possible to increase the yield up to 400-600 therms per ton, without the calorific value falling below 500 B.Th.U./cu. ft. In this way 70 to 85 per cent. of the carbon of the coal is gasified. The sulphur is hydrogenated to hydrogen sulphide.

The influence of alkalies was most marked with hydrogenated coke at relatively low temperatures. A coke prepared from an intimate mixture of coal and 3 per cent. by weight of sodium carbonate gave 463 therms per ton in gaseous hydrocarbons, when hydrogenated at 800° C. Without alkali the yield was only 140 therms. That these processes are regarded hopefully goes without saying. Further investigations are being pursued on organised lines.

In connection with the above processes it is interesting to observe that the I.G. have covered[4] the use of catalysts for $CO-H_2$ conversion.

Simultaneous Production of Sulphuric and Nitric Acids

The simultaneous production of sulphuric and nitric acids has been the subject of much consideration, and plant development, during the last five or six years. Such a process (Kachkaroff-M.-P.) has two outstanding features. By passing large quantities of oxides of nitrogen in excess of what is required for the manufacture of sulphuric acid through tower chambers, the space-time factor is reduced appreciably, and the production of sulphuric acid per unit volume reaches phenomenal figures.

Moreover, the "nitroses" formed by the absorption of the regenerated oxides of nitrogen need only be returned in part to the Glover tower for denitration. The bulk can be passed to a silicon iron denitrating column, and the nitrogen oxides recovered in the form of nitric acid, 60 per cent. HNO_3. The absorption towers for such plant need only be relatively small, as the nitric acid vapours are free from diluent gases.

The process can be varied at will, so as to produce a negligible quantity of nitric acid and a considerable quantity of sulphuric acid, under intensive conditions, or units contemplating the manufacture of varying proportions of sulphuric and nitric acids can be arranged.

For the production of sulphuric acid the plant will consist of an ammonia oxidation unit with Glover tower, a tower

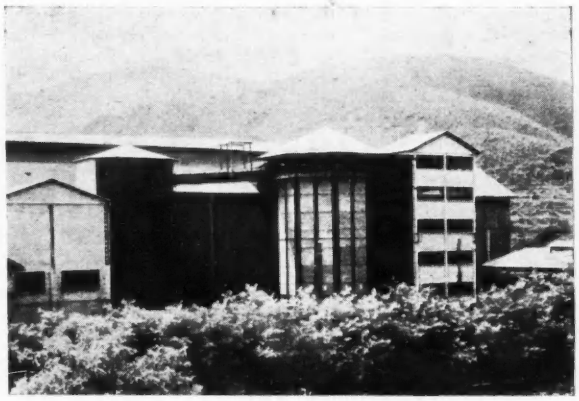


Fig. 1. General view of Kachkaroff-M-P combined sulphuric and nitric acid plant.

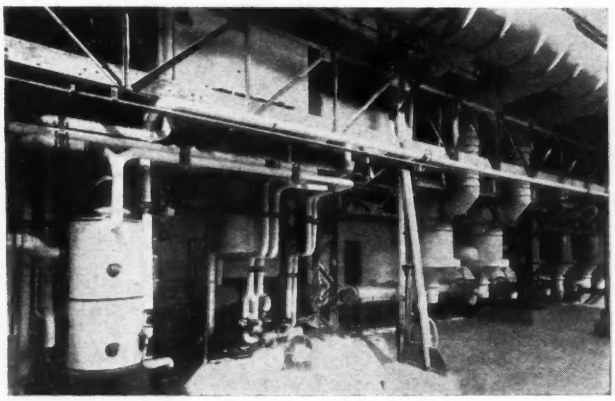


Fig. 2. Converters (ammonia oxidation) of a Kachkaroff-M-P sulphuric-nitric acid plant.

for the regeneration of nitric oxides and one or two suitable Gay Lussac towers.

For the production of sulphuric and nitric acids the plant will comprise ammonia oxidation units (in which concentrated ammonia liquor, 25 per cent., can be used), a special form of sulphuric acid plant embodying Glover tower, a tower for the regeneration of nitric oxides and Gay Lussac towers, and finally denitration plant with absorption towers for the recovery of the oxides of nitrogen as nitric acid, 60 per cent. HNO_3.

Fig. 1 shows a view of a plant producing daily 40 tons of sulphuric acid (monohydrate) and 20 tons of nitric acid, 100 per cent. Fig. 2 shows the converters in connection with this plant. It is peculiarly applicable to the utilisation of concentrated ammonia liquor and concentrated gas liquor, and would admit of a variety of nitrogenous and other fertilisers being manufactured under such conditions of flexibility and economy as can hardly be attained by other processes.

Sulphuric Acid

A study of the economics of the sulphuric acid industry has been made by Kreps. It is a book containing information of a most valuable character, but it does not appear to have received the notice that it merits.

Pickling bath inhibitors involving the use of creosote, 55° Bé. sulphuric acid and thiocarbanilide are covered by B.P. 477,425.

The feature of the Kestner-Fakler process[3] for the utilisation of waste pickle liquors lies in its high recovery of acid and ferrous sulphate.

An ideal reaction chamber for the conversion of SO_2 to SO_3 has been devised by G. Fauser.

Some details of the Greek tower process for the manufacture of sulphuric acid erected at the Piraeus Works of the Société Hellenique de Produits et Engrais Chimiques have been afforded.[4] The main feature of the plant is a void chamber, measuring some 600 cubic metres, for the regeneration of the nitric oxides.

The author made similar provision three years ago, in connection with a sulphuric acid plant that he designed, adopting a special nitration process, in which the H_2S of saturator gases was the raw sulphur material. It has to be remembered, in connection with packed tower systems, that the oxidation of sulphur dioxide is effected exclusively by nitric oxides, the reoxidation of which is a sensitive reaction, involving considerable time. Generally speaking, these packed tower systems rely on the regeneration being effected in the Glover towers: hence, as A. Georgiu has pointed out, only 10 to 20 per cent. of the nitric oxides is absorbed by the Gay Lussac tower.

As regards the Greek tower process, and the regeneration of nitric oxides until the phase $NO.NO_2$ (which is most favourable to absorption) has been reached; the following principles should be observed:—

(1) If possible 50 per cent. of the nitric oxides should be oxidised until nitrogen dioxide is obtained.

(2) The equilibrium of oxidation $2NO + O_2 \rightleftharpoons 2NO_2$ depends upon the temperature. Below 130° C. the reaction is entirely towards the left.

(3) At ordinary atmospheric temperatures, regeneration is more rapid the lower the temperature. At 25° C., for example, the rate of oxidation is three times as great as that at 90° C.

(4) According to Bodenstein's findings, regeneration increases proportionately with the concentration of oxygen and with the square of concentration of nitric oxides.

Dr. H. J. Bush has made reference[5] to the success attending the introduction of a process for the production of sulphuric acid by the use of a wet vanadium catalyst from saturator gases, for the installation of which his company, Huntington, Heberlein and Co., Ltd., was responsible. He has remarked that the plant is producing regularly the equivalent of more than 10 tons of monohydrate per day, in the form of 90 to 92 per cent. acid, and that the overall efficiency is not less than 95 per cent., even under the difficult conditions

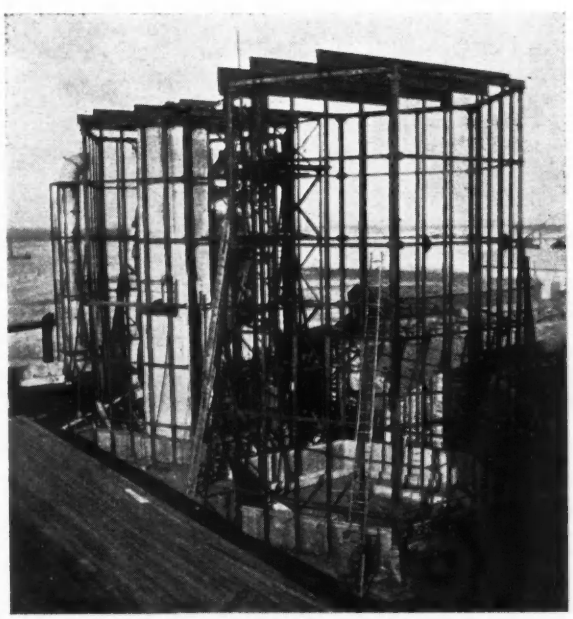


Fig. 3. Gaillard-Parrish hexagonal tower chambers in course of erection.

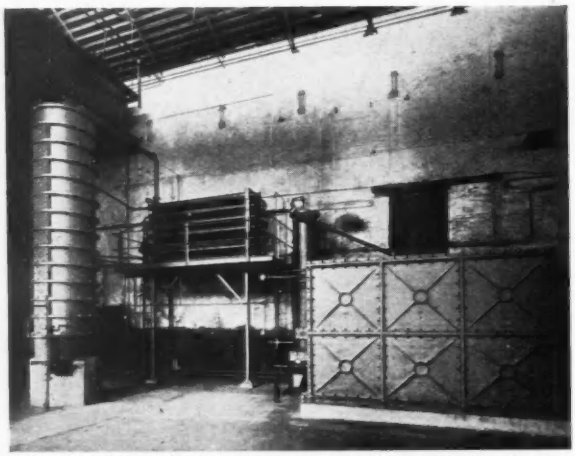


Fig. 4. Plant for the production of concentrated gas liquor, containing 20-22 per cent. ammonia by weight, erected by Newton, Chambers and Co., Ltd., at the Norwich works of the British Gaslight Co., Ltd., comprising automatically-controlled still, preheater-condenser, scrubber and storage tank.

associated with the use of saturator gases of a low H_2S content.

Dr. Bush, in dealing generally with the subject of electrostatic precipitation, has remarked that this cannot yet be termed a science. It is still an art, and likely to remain so until the individual parts played by the many factors present together in the electrical field have been examined in an organised way. What is being done to-day is intelligently to correlate the voluminous data obtained from actual working conditions with the potential gradients of the high-tension current, the time exposure, the linear gas velocity and other factors. In this way it is hoped to establish constants to enable plant to be designed for any required degree of dust recovery from any one type of gas.

In connection with electrostatic precipitation plants it should be remarked that several firms are finding difficulty in the disposal of the very fine dust which is recovered, and apparently there is no market for this product. The author dealt with this aspect in the 1932 review.

A method of cheapening the cost of the construction of Gaillard-Parrish tower chambers, involving the use of a wooden framework of pitch pine, has previously been described.[8] A further step has now been taken, by the adoption of hexagonal-shaped chambers constructed of a light skeleton steel framework, to reduce the cost of the erection of the lead very appreciably. Fig. 3 shows three such tower chambers in course of erection.

During the present year a large number of turbo dispersers has been supplied for application to water-cooled tower chambers at works in South Africa and New Zealand. That the dispersion of cooled acid augments production in tower chambers hitherto regarded as intensively-operated, has been demonstrated beyond doubt.

A reminder of the value of platinum catalysts for the conversion of sulphur dioxide to sulphur trioxide, their rôle in war-time plants, and the high scrap value that the used material possesses, is forthcoming from Mr. R. H. Atkinson.[9] In United States plants, per ton/day of 100 per cent. sulphuric acid, 5.5 to 7 oz. troy of platinised asbestos, or platinised magnesium sulphate, is now required, and only 1.5 to 2.1 oz. of platinised silica gel, as contrasted with war-time requirements of 13 to 16 oz.

Pressure processes for the production of caustic soda and sodium carbonate are still the subject of keen interest, and more will be heard of these methods in the near future.

The warning to which reference was made in the 1936 review, about chlorine-caustic soda balances as affecting the United States market, is recalled when one learns how the Pomilio pulp production process[10] solved the problem of the disposal of large quantities of electrolytic chlorine. The process consists of a mild pre-treatment or digestion of the fibrous raw materials with diluted caustic soda solution at boiling temperature under atmospheric pressure. The second step is the exposure of the most porous pre-digested raw materials to gaseous chlorine in the cold for such a limited time as is necessary to form the organic chlorine derivatives, especially chlor-lignins. The second stage takes place in an acid medium, owing to the formation of hydrochloric acid resulting from the combination of displaced atomic hydrogen with elementary chlorine. Of the several chlor-lignins formed, most are water-insoluble, but one is water-soluble.

The Pomilio process has, it seems, been found applicable to every raw material tried. Its main appeal to U.K. and Empire pulp producers will be found to lie in its employment with wheat-straw, esparto and other grasses, and bamboo pulp.

The sale of salt by Rumania to Japan is reported.[11]

Non-caking kitchen salt[12] which can be readily strewn or poured can be prepared by the addition of a calcium compound of lactic acid to ordinary kitchen salt. This compound may be either calcium lactate or a double lactate of calcium and sodium.

The oxalate process for manufacturing caustic soda is covered by B.P. 477,230. Caustic soda is prepared by reaction with, in the presence of water in a *volatile* alkali, a suitable metal oxalate and a soluble sodium salt, *e.g.*, a chloride or nitrate, the acid radicle of which forms a soluble calcium salt to precipitate sodium oxalate. This is causticised with lime to give sodium hydroxide, with a precipitate of calcium oxalate, and reacting this precipitate with the mother liquor from the first stage, after removing at least part of the volatile alkali and adding acid to dissolve soluble constituents of the resulting precipitate, to precipitate the original metal oxalate. Suitable metal oxalates include those of copper, zinc, nickel, silver, cobalt and cadmium. Ammonia is the preferred alkali.

The purification of caustic soda solutions by Imperial Chemical Industries, Ltd., is covered by B.P. 475,937.

By-Product Ammonia

The Institution of Gas Engineers has recently published a book on the subject of "Gasworks Effluents and Ammonia," by Dr. A. Key. It summarises the work of the Liquor Effluents and Ammonia Committee over a period of several years. It will prove invaluable to those gasworks and coke ovens which are faced with liquor effluent-disposal problems, and to those who are anxious to know how their gas liquor can be economically treated.

Five distinct types of Thorncliffe-Baldurie plant have now been erected for the manufacture of concentrated gas liquor, dependent on the characteristics and chemical composition of the gas liquor to be dealt with. It is only by judicious discrimination in the selection of the correct type of plant that economy in the manufacture of concentrated gas liquor can be ensured. Where weak gas liquors are involved a two-stage process has been developed. Where partial decarbonation is necessary, in order to reach a concentration of 20 to 22 per cent. of ammonia by weight, this may be effected initially in a dissociator; or almost at the end of the condenser by evolving gases at certain specific temperatures, in order to remove CO_2 with a minimum of ammonia. Such gases are passed to a scrubber, which is fed with gas liquor. This process is covered by B.P. 494,023 (see Fig. 4). That concentrated gas liquor production and central schemes are developing appears certain from the figures given in the Alkali Report for 1937, where the manufacture is given as the equivalent of 112,200 tons of concentrated gas liquor, 25¾ per cent.

Attention has recently been given to methods[13] for improving the quality of by-product sulphate of ammonia at gasworks and coke ovens, with a view to obtaining a hard crystal of satisfactory size, 3 : 1 length-to-breadth ratio, neutral and dry, and of satisfactory whiteness. When ammonium sulphate is crystallised in acid solutions containing small

quantities of aluminium, chromium or ferric iron, slender thin crystals are formed, which are fragile. It is suggested that the addition of oxalic acid to the bath liquor of acidities ranging from 2½ to 8 per cent. constitutes the simplest known method of obtaining control.

What should be remembered is that most saturators are unnecessarily large, and are not provided with suitable means for the support of the crystals in the mother liquor, from which they can alone grow, for a sufficient time. Given the correct dimensions and design of saturator, and suitable control, it is an easy matter to prepare a satisfactory hard crystal of a size which is not fragile. With spent oxide-acid of known quality there should be little need for the removal of the ferric iron as a complex ferrioxalate. Indeed, most saturators are operated under the reducing influence of H_2S, with the possibility of traces of SO_2 being retained in the sulphuric acid until it reaches the bath.

It has been pointed out by Sanfourche and his colleagues that there is distinct merit, particularly from the point of view of the quality of calcium superphosphate, in the trace elements of sulphuric acid manufactured from pyrites. This applies in a lesser degree to sulphuric acid manufactured from spent oxide.

The sale of calcium superphosphate has declined slightly during the year. But perhaps the subsidy accorded to basic slag by the Land Fertility Scheme, has, in part, been responsible for this. That superphosphate manufacturers feel aggrieved by the somewhat indiscriminate treatment which has been meted out is known.

Consolidation of the superphosphate industry continues. The old-established works of Charles Norrington and Co., Ltd., and Burnard and Alger, Ltd., at Plymouth, Spooner and Bailey, Ltd., at Southampton, and Avon Manure Co., Ltd., at Bristol, have now ceased to produce calcium superphosphate. Their trade has been absorbed by National Fertilisers, Ltd., of Avonmouth, a company owned fifty per cent. by Fison, Packard and Prentice, Ltd , and fifty per cent. by the Imperial Smelting Co., Ltd.

Continental investigations have revealed that the efficiency of application of the old quality of calcium superphosphate, and compound fertilisers containing that product, was low. Steps have been taken on the Continent and in this country to manufacture granular fertilisers, which are known to have a much higher efficiency of application. The size of the granules generally ranges from 1 to 1.6 mm., and from 1.6 to 3.5 mm. Fison, Packard and Prentice, Ltd., at Ipswich, and National Fertilisers, Ltd., at Avonmouth, are manufacturing something of the order of a hundred thousand tons of such granular calcium superphosphate per year by the Oberphos process. This is an autoclavic one, in which ground phosphate rock is digested in sulphuric acid under pressure, and in connection with which steam is applied to the jacket of the autoclave. After twenty-five minutes or so the pressure is released, and the steam, carbon dioxide, hydrofluoric acid and other products of decomposition are withdrawn by vacuum. The superphosphate emerges in hard lumps, and can be ground and screened to give granules of varying sizes.

Dense calcium superphosphate made in the normal way can be nodulised by adding a small quantity of water (some processes do not require water, but involve the addition of phosphoric acid or monocalcium phosphate), agitating it at atmospheric pressure and temperature in a special form of equipment. No intermediate storing or maturing period is called for.

The excess moisture must be removed immediately following the granulating process, by drying with heat at atmospheric pressure during the time that granulation is proceeding. The water content of the granules is of the order of 3 to 4 per cent.

The size of the granules of the agglomerated superphosphate arising at the discharge end of the mixer, or conditioner, is a function of the quantity of acid added. The granular material should remain in the store for three days to a week, during which period the nodules become very much harder and have a crushing strength several times that of the fully-matured superphosphate.

Any tendency to form "fines" in the final product can be counteracted by increasing the rate of atomised water fed: on the other hand, if any undue quantity of "oversize" is being produced, the rate of additional water is reduced.

The mechanism underlying this apparently simple process is intriguing. It is largely a question of the surface tension of certain solutions. The free acid in calcium superphosphate is essentially phosphoric acid. Any sulphuric acid present is limited to a trace. Judicious and uniform wetting redistributes the phosphoric acid, and may promote the hydrolysis of the monocalcium phosphate. On drying, phosphoric acid is concentrated, and this factor, aided by the influence of the elevated temperature in the dryer (90° C.), facilitates granulation. Drying the superphosphate after granulation improves the physical condition, and on storage admits of the granules hardening, so that they do not cake, provided deposited moisture is avoided.

Several processes have been developed, among which are the A.B. Kemiska Patenter (Landskrona), in which Sven Nordengren is chiefly interested: the Davison Chemical Corporation, Baltimore (B.P. 491,841), and the Parrish-Ogilvie.

Compound fertilisers constituted of varying proportions of calcium superphosphate, sulphate of potash and sulphate of ammonia are being granulated by methods similar to the above, and recently Fison, Packard and Prentice, Ltd., have opened a new factory, for the production of 50,000 tons per year of such granular compound fertilisers. This represents a distinct advance of technique, which is bound to be appreciated by agriculturists.

The Tennessee Valley Authority, of America, is producing a glass fertiliser—calcium metaphosphate—which varies in colour from light straw to dark brown. In the lump form it is quite stable, but when ground becomes deliquescent, absorbing water and changing from meta to the soluble phosphate. The deliquescence can be prevented by the incorporation of ground calcium carbonate. No information appears to have been published yet concerning the manurial value of this glass fertiliser, but it is understood that experiments are in hand to determine its suitability and value. The Tennessee Valley Authority manufactures phosphorus by a combustion method, of which full details appeared in a contribution[11] entitled "Process Developments at T.V.A.: Phosphoric acid plant," by H. A. Curtis, A. M. Miller and R. H. Newton.

Little appears to be known concerning the physical characteristics of rock phosphates. An attempt to afford information on this subject has been made by Dr. Alaschewsky (Saarau), by microscopic examination in polarised light. By means of the polarisation-microscope it is possible to differentiate between refracting and double-refracting substances, as well as to magnify. The individual constituents, their structure, relative quantities, special distribution, etc., can be determined after a certain amount of practice.

Interesting information, as a result of these examinations, has been afforded in a paper given to a technical meeting in Hamburg.[15]

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[1] *Chemical Age*, *39*, 311.
[2] *Ibid.*, *38*, 325.
[3] *Ibid.*, *39*, 319.
[4] B.P. 473,972.
[5] *Chemical Age*, *38* (Metallurgical Section), 33.
[6] *Chemical Trade Journal*, *102*, 197.
[7] *Chemical Age*, *38*, 13.
[8] *Ibid.*, 1936 Review Number.
[9] *Ibid.*, *39*, 368.
[10] *Chemical Trade Journal*, *102*, 193.
[11] *Ibid.*, *102*, 460.
[12] B.P. 478,629.
[13] *Gas World*, Coking Section, Dec. 3, 1938, 15 *et seq.*
[14] *Chemical & Metallurgical Engineering*, *45*, No. 4, 193 *et seq.*; *Chemical Age*, *38*, 89.
[15] *Chemical Trade Journal*, *102*, 238.

The Institution of Chemical Engineers

A Year of Consolidation and Material Progress

At the 16th annual corporate meeting, held on February 18, 1938, Dr. William Cullen was elected President for a second term of office. Under his able guidance the Institution has had a year of considerable activity, during which the expansion in membership has been well maintained, and, in fact, the total passed the 1,000 mark during November. The joint honorary secretaries, Dr. A. J. V. Underwood and Mr. M. B. Donald, and the honorary treasurer, Mr. F. A. Greene, continued in their respective offices during the year. The new elections to Council for the year were: Captain W. H. Cadman, Dr. A. Parker, Mr. H. V. Potter and Dr. J. C. Swallow. The President's address, "A Milestone," was of particular interest, ranging over a very wide field of subjects of interest to the Institution.

The Moulton Medal for 1937 was presented to Mr. M. B. Donald for his paper "Percolation Leaching in Theory and Practice," and the Junior Moulton Medal and prize of books was awarded for the paper on "Industrial Alcohol" by Mr. W. H. A. Webb. The Osborne Reynolds Medal was presented to Mr. C. S. Garland for his unceasing interest in the advancement of the Institution's affairs and the William Macnab Medal, for meritorious work in the Associate-Membership examination, was awarded to Mr. M. J. van der Zijden, an entrant from Holland.

A noteworthy feature of the programme of meetings during the year has been the holding of joint meetings with other bodies, particularly the three senior engineering institutions, to discuss matters of "borderline" interest. The variety of the papers read is indicated by the following titles: "The Treatment and Disposal of Trade Waste Waters," by Dr. A. Parker (joint meeting with the Institution of Civil Engineers); "Some Applications of Electrical Precipitation to Industrial Effluent Gases," by Dr. H. J. Bush; "Some Theoretical and Commercial Aspects of Flocculation," by Mr. J. O. Samuel; "Size Analysis by Photographic Sedimentation," by Mr. W. F. Carey and Mr. C. J. Stairmand; "Electrolysis: Principles of Plant Design and Operation," by Dr. H. J. T. Ellingham (joint meeting with the Institution of Electrical Engineers); "Engineering Problems associated with the Improvement of Temperature and Humidity Conditions of the Atmosphere in Mines at Great Depths" by Dr. J. H. Dobson and Professor W. J. Walker (joint meeting with the Institution of Mechanical Engineers); "Chemical Engineering in the Fermentation and Distilling Industries," by Dr. R. Gilmour (joint meeting with the Society of Chemical Industry), "Principles and Practice of Rating of Industrial Concerns," by Mr. P. Michael Faraday (joint meeting with the Incorporated Association of Rating and Valuation Officers); "Azeotropic Distillation in Industry" by Monsieur H. Guinot and Mr. F. W. Clark; "The Principles of Design of Modern Industrial Furnaces" by Mr C. Webb.

The public lecture of the year was the occasion of the third Hinchley Memorial Lecture, when a large audience attended Professor J. C. Philip's address on "Fog and Mist from the Physico-Chemical Standpoint."

The Graduates and Students Section held seven meetings during the year, in addition to the annual informal dinner, at which the President was the principal guest. At the annual meeting of the section, Mr. S. H. J. Burgess was elected chairman for a second year, and Mr. R. F. Hayman succeeded Mr. A. P. Buchanan as honorary secretary.

The thirteenth examination for Associate-Membership was held during the year. There were four entrants, of whom three satisfied the examiners. A party of Danish students of chemical engineering who visited this country in June was entertained to tea by the Council.

While there has been no event of outstanding importance, the Institution can look back with satisfaction on a year of consolidation and material progress.

The Chemical Society

A Review of Activities during 1938

During 1938, the Chemical Society has held 16 scientific meetings in London, and 31 scientific meetings in various centres outside London. The scientific meetings held in London comprised six lectures, four organised discussions and six meetings at which 19 papers were read and discussed. The following lectures were given:—The Sixth Pedler Lecture entitled "Synthesis of Polyenes," by Professor Dr. Richard Kuhn; a Memorial Lecture on the Life and Work of Professor E. C. Franklin, by Professor Alexander Findlay; "Nucleic Acids," by Professor J. M. Gulland; "Some Carbohydrate Problems," by Professor W. N. Haworth; the Seventeenth Faraday Lecture entitled "Monolayers on Solids," by Dr. Irving Langmuir, and the Perkin Centenary Lecture entitled "Sir William Perkin's Adventure and What Has Come of It," by Dr. Herbert Levinstein (held under the auspices of the Chemical Society and the Society of Chemical Industry). The titles of the discussions were:—"Associated Liquids," opened by Professor J. D. Bernal; "Electron Diffraction and Surface Structure," opened by Professor G. I. Finch (jointly with the Physical Society); "Organic Intermolecular Complexes," opened by Professor G. M. Bennett and "Aggregation on Ions in Paraffin-Chain Salt Solutions," by Dr. G. S. Hartley.

Anniversary Meetings.—The anniversary meetings of the Society were held in Manchester, the 97th annual general meeting taking place in the University on March 31, and the anniversary dinner being held at the Midland Hotel the same evening. On April 1, visits of interest were arranged for the morning; in the afternoon Professor G. Barger gave a lecture on "The Life and Work of Amé Pictet," and in the evening the Council of the University of Manchester invited Fellows to a reception.

Of the 31 meetings held outside London, 25 were devoted to lectures and six to the reading of original papers.

Fellowship.—In 1938, 226 Fellows were elected and 15 reinstated, the number of Fellows now being 3,809. Five honorary Fellows were elected.

Journal.—The Journal contained 404 original papers, 34 notes and lectures, occupying in all 2,120 pages. Volume XXXIV of the Annual Reports on the Progress of Chemistry for 1937 (issued in 1938) contained 540 pages. In accordance with a decision reached in 1937, every paper is accompanied by a short summary of its contents.

Abstracts "A."—As from the beginning of 1938 Physiological Abstracts, which had previously been issued as a separate publication, has been incorporated with British Chemical Abstracts "A" (Pure Chemistry), in accordance with an agreement entered into between the Biochemical Society, the Physiological Society, the Society of Chemical Industry and the Chemical Society in July, 1937, the Bureau being reconstituted as "The Bureau of Chemical and Physiological Abstracts." Abstracts "A" now includes three sections: I, general, physical and inorganic chemistry; II, organic chemistry, and III, physiology and biochemistry. In 1938, AI contained 644 pages, AII 518, and AIII 1,066.

Research Fund.—Grants amounting to £695 were distributed to 84 Fellows, the sum applied for being £967.

Library.—The use of the library made by Fellows and members of the contributing Societies continues to increase. In 1937, there were 8,554 attendances of which 4,988 were made by Fellows and 3,566 by members of other constituent and contributing bodies. The number of books borrowed was 5,666 and the total number of volumes added was 1,012. The library contains 42,500 volumes.

Other matters engaging the attention of the Council during 1938 include the introduction of a scheme for the territorial representation of Fellows on the Council, which will come into operation in 1939. The serious problem of further accommodation for administration and library purposes is now being considered.

The Nitrogen Industry in 1938

By
E. B. MAXTED, D.Sc., Ph.D., F.I.C.



Dr. E. B. Maxted.

ALTHOUGH there has been no great change in the position of the nitrogen industry during the past year, the present economic and political position in the various countries of the world may perhaps be responsible for the certainly greater volume than usual of published work, and particularly of patents, in this field. The subjects of this work vary considerably with the particular country concerned: thus, outside Russia, the synthesis of ammonia appears now to be sufficiently standardised for relatively few new papers and patents to appear, yet, in Russia itself, a large number of papers dealing both with the preparation and properties of ammonia catalysts from natural iron ores and with the synthesis generally, continue to be published; and, while many of these necessarily only amplify what is largely already known, the quantitative details contained in them now constitute an important body of published work available to the general reader. Of other nitrogen compounds, the production of cyanides has, as in former years, been the subject of considerable work both in European countries generally and in America. This can be understood from the increased use of hydrocyanic acid and cyanides for the destruction of pests as well as in gold extraction.

General sales and prices continue to be regulated by international agreement along lines similar to those obtaining in previous years; and, from the standpoint of the extension of the British synthetic nitrogen industry overseas, it may be noted that Imperial Chemical Industries, Ltd., are stated to be erecting a new synthetic ammonia plant at Melbourne for the manufacture of ammonia and nitrates in Australia.

The following short review of representative work published during the year is arranged under the usual headings.

Synthesis of Ammonia

The production of ammonia catalysts from natural (Krivoi Rog) hæmatite has been investigated by V. M. Grinievitsch and S. V. Klapschuk[1] and supplements analogous work carried out in earlier years with other natural iron minerals: indeed, in the author's experience, hæmatite constitutes a very suitable basis for catalysts of this nature. The influence of various factors in the reduction of iron ammonia catalysts has also received attention. S. S. Latschinov[2] finds that it is beneficial from the standpoint of the resulting activity to employ a hydrogen current which is fast enough to carry away effectively the water as it is formed; and, in accordance with general experience, Latschinov observed that raising the temperature shortens the reduction time but decreases the activity. Increase in pressure was also found to lower the activity, especially at low space velocities of passage of hydrogen. It may be noted, in this connection, that it is common practice with most catalysts of this type, not only to avoid a rapid reduction by using a low temperature and pressure, but also to dilute the reduction hydrogen with nitrogen to decrease the reduction rate still further.

In connection with the removal of ammonia from the circuit gases, J. W. Davis[3] has protected a compound cooling method of the type in which a second and lower stage of indirect cooling of the gas is obtained by injecting air into liquid ammonia. The action of traces of lubricating oil, such as are carried along with the compressed gases, on the activity of ammonia catalysts has been studied by V. P. Kamzolkin and V. D. Livschitz.[4] Considerable deactivation, as is well known, may occur in this way. Other points in connection with the synthesis which have been investigated during the year include special steels for the catalyst vessels, for which A. V. Smirnoff[5] recommends a steel containing 6 per cent. of chromium, 0.5 per cent. of molybdenum and about 0.2 per cent. of carbon.

The purification of the nitrogen-hydrogen synthesis gas from carbon monoxide is dealt with by S. Kazarnovski, V. Borschevski and D. Koster[6], who state that treatment with hopcalite at 100° results in the substantially complete conversion of the carbon monoxide into dioxide if oxygen is also present in the gas. A further development of the synthesis has been discussed by the Norsk Hydro-Elektrisk Kvaelstofaktieselskab[7]. As is well known, considerable quantities of argon and other rare gases accumulate in the circuit. This company propose the use of a separate furnace, which may be similar in construction to a normal ammonia synthesising chamber, for the further concentration of these gases. As the content of the rare gases rises and that of the nitrogen and hydrogen falls, special heating will be required to maintain the reaction.

Nitric Acid and Nitrates

The oxidation of ammonia to nitric acid continues to be investigated. V. A. Klevke and M. R. Chajkin[8] have discussed the purification and general cleaning of ammonia and air for ammonia oxidation plants. Suitable measures include the use of filters to remove dust, lubricating oil and iron particles. The stabilisation of the composition of the ammonia-air mixture, by passing this through an ammonia solution of the appropriate vapour pressure has also been suggested by R. S. Richardson.[9] Several patents deal with catalysts for the reaction: thus, the Interessengemeinschaft[10] have protected the use of mixed platinum metals in conjunction with zirconium, and U. F. Bray[11] has proposed a base metal catalyst containing cobalt with only traces of nickel. As a variant of the usual way of working, the Bataafsche Petroleum Co.[12] have described an oxidation process in which the ammonia and air are forced through porous material containing a suitable metal, such as platinum. Finally, I. E. Adadurov and B. A. Grigoriev[13] have investigated the loss of platinum from catalyst gauzes during the operation of these. This loss is stated to be entirely due to low-temperature sublimation.

Several workers have paid attention to problems in condensation and concentration. A. Christensen[14] has discussed improvements in the absorption of nitrogen oxides by counterflow methods in which dilute nitric acid flows in the reverse sense to the gas; and the concentration of nitric acid by means of a countercurrent of steam under reduced pressure in a special type of plant has been protected by T. Hobler.[15] The optimum arrangement, from the standpoint of relative size, of successive absorption towers has been considered by W. Rudbach,[16] who recommends the employment, alternatively, of a small absorption and large oxidation tower in a series in which the size of the oxidation towers (in which the oxidation of nitric oxide to higher absorbable oxides takes place) progressively increases as the nitric oxide becomes more dilute.

The Du Pont de Nemours Co. has described a process[17] for the concentration of nitric acid according to which the hot aqueous acid is brought into contact with hot sulphuric acid, containing a slight excess of trioxide, in a column, when much of the concentrated nitric acid is distilled off by means of the reaction heat. The sulphuric acid is subsequently

denitrated and concentrated by a current of gaseous sulphur trioxide. A further specification dealing with the denitration of sulphuric acid containing nitric acid is due to W. Busching,[18] who employs the vapours of sulphuric acid under special conditions.

Passing to processes for the manufacture of nitrates, J. H. Shapleigh[19] has dealt with a method of production of ammonium nitrate by absorbing oxides of nitrogen, for instance, from an ammonia oxidation plant, in a closed circuit fed with ammonium nitrate solution to which ammonia is added, and the Staatsmijnen in Limburg[20] have described a concentration process for ammonium nitrate of the type in which use is made of the heat of neutralisation. The production of a special fertiliser containing ammonium and calcium nitrates has been claimed by the Stockholms Superfosfat Fabriks Aktiebolaget.[21] This is prepared by mixing limestone and acid ammonium nitrate under conditions for which reference should be made to the original specification.

The formation of sodium nitrate by the action of nitric acid on salt has been discussed by B. Vasiliev and Y. Ravdin.[22] In addition to sodium nitrate, chlorine and nitrosyl chloride are produced. A further process of this type has been protected by H. A. Beekhuis,[23] who proposes a method of making sodium nitrate which includes the evaporation under reduced pressure of a solution consisting of sodium or potassium chloride, nitric acid and a mother liquor from a previous operation. A process of another type has been described by the Norsk Hydro-Elektrisk Kvaelstof-Aktieselskab,[24] sodium nitrate being produced by the interaction of sodium chloride solutions (e.g., sea water) with calcium nitrate.

Ammonium Salts

A discussion of the production of by-product ammonia with special reference to the design of the absorbers has been published by E. Thau[25]. Diagrams are given of various absorbing systems, and factors governing the production of ammonium sulphate of specified size and purity are discussed. The year's patents have included the usual group governing the manufacture of coarse crystals, principally of the sulphate, by adding small quantities of other salts. Thus, C. Rumscheidt and A. Stryzewski[26] have protected the use of chromium sulphate, and the Interessen-Gemeinschaft[27] have extended a previous proposal to the obtaining of coarse crystals of ammonium sulphate by evaporating solutions of this together with aluminium salts and salts of the alkali metals, for instance a mixed solution of ammonium sulphate, aluminium sulphate and sodium chloride. A further patent covering the addition of phosphoric acid or of phosphates to ammonium sulphate for producing large crystals has been published by G. Berkhoff;[28] and ammonium chloride in coarse crystalline form is, according to C. H. Heimbach,[29] produced by adding cadmium chloride and acid ammonium phosphate. A method involving the use of a disc spray, for the production of granular ammonium salts, particularly the nitrate, has been described by the Du Pont de Nemours Co.,[30] the size of the granules being regulated by adjusting the rotational speed of the spraying disc. A further procedure for the manufacture of coarse crystals of ammonium bicarbonate, by adding carbon dioxide and ammonium carbonate solution to a solution of the bicarbonate at a sufficiently slow rate to give time for the crystal growth, has been described by the Interessen-Gemeinschaft.[31] The concentration of ammonia liquor may perhaps also be mentioned here. J. L. Bennett[32] has patented a process of the type in which the dilute ammonia solution is allowed to interact with an ascending current of steam in a concentration tower through which the ammonia and steam flow in countercurrent to one another; and it may also be noted that S. Pexton and E. H. M. Badger[33] have re-measured the vapour pressures of ammonia and carbon dioxide over aqueous solutions of these at 20-40°.

Other Nitrogen Compounds

Further work on the production of hydrocyanic acid by passing a mixture of a hydrocarbon and ammonia through a heated tube under special conditions has been done by H. Tramm and W. Grimme;[34] and the substantially complete conversion of formamide by dehydration with a granular manganese dioxide catalyst at about 550° has been claimed by the Du Pont de Nemours Co. and A. T. Larson.[35] Other work on the same subject has been carried out by this company and E. P. Bartlett.[36] The formamide is vaporised in the presence of silica or alumina and immediately passed over the manganese oxide catalyst. The yield is stated to be 96-98 per cent. of theory. A further, somewhat similar process, which has been described by E. Hene, consists in heating ammonium thiocyanate or thiourea with finely divided copper.[37]

A number of improvements in various methods of making cyanides have been published during the year. Thus, according to a process of E. C. Moffett and the American Cyanamid Co.,[38] sodium chloride is fused with calcium cyanamide and carbon, the melt being subsequently heated with sodium carbonate. Sodium cyanide may be separated from the product by the action of ammoniacal methyl alcohol. L. J. Christmann,[39] further, has proposed the precipitation of sodium cyanide from solution by adding a solvent which is miscible with the solution, but in which the cyanide is insoluble; and L. J. Burrage and Imperial Chemical Industries,[40] dealing with a different method of manufacture, have described the use of special types of coal for the production of alkaline cyanides by the reaction of carbon with an alkali amide. The manufacture of calcium cyanamide with special reference to temperature control has been discussed by Devèze[41]; and A. Lotz[42] has protected a method of producing calcium cyanamide according to which the calcium carbide, in granules of controlled size, is added continuously to a circuit in which the nitrogenation of the carbide is carried out. N. Caro has described the preparation of calcium cyanamide from phosphatic rock.[43] This is first of all heated with carbonaceous matter until the phosphorus has been distilled off, as the pentoxide, when the temperature is raised to 1,600° or over, with formation of calcium carbide. Nitrogen is then passed over this at a lower temperature in the ordinary way. For the purification of calcium cyanamide, the Bayerische Stickstoff-Werke[44] remove any calcium carbide or lime by the action of just sufficient steam for the purpose. According to a proposal of the Interessen-Gemeinschaft,[45] the free lime is neutralised with an acid phosphate and the product is made into a fertiliser.

Finally, some attention has been paid to the synthesis and use of urea. Passage of the ammonia and carbon dioxide through a liquid such as glycerine at a temperature high enough to avoid the condensation of ammonium carbonate has been recommended by the Compagnie de Produits Chimiques[46] as a method of dehydration. The conversion of urea into sulphamide has been described by M. E. Cupery.[47] Sulphamide and its salts have many uses, including the application of ammonium sulphamate as a flame-proofing agent for textiles or paper. It may also be noted that B. A. Bolotov and others[48] have reviewed the general position of the large-scale synthesis of urea from carbon dioxide and ammonia.

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The Institute of Petroleum

Important Alterations in Constitution Made this Year

THE year 1938 has been an important one for the Institute of Petroleum. At the annual general meeting in March extensive alterations were made in its constitution. The Institute was founded in 1913 as the "Institution of Petroleum Technologists," and in order to provide scope for future development and a broader basis for the Institute's activities, changes in the memorandum and articles were approved by the members and received the sanction of the court in May. The name was changed to that of the "Institute of Petroleum" at the same time.

Under its new constitution the Institute will attract to its membership those associated with the administrative, distributing and economic aspects of the petroleum industry, in addition to those engaged on the purely technical side.

In June the Institute organised the first International Conference on oil shale. This was held in Glasgow from June 6 to 11, and was attended by over 300 visitors, including many from overseas countries. The conference received the patronage of H.M. Government and the support of the authorities of the Empire Exhibition. Thirty-two papers were presented dealing with different aspects of the geology, mining, refining and utilisation of oil shale and cannel coal. The proceedings of this conference have recently been published and form a valuable collection of up-to-date information on the problems of obtaining oil from sources other than natural petroleum.

Study Groups Formed

One development of the changes in the constitution of the Institute is the formation of groups for the study of special subjects. Two such groups have been formed during the present session. A Lubrication Group was inaugurated in October with a symposium of papers on cutting oils. On December 13 an Asphaltic Bitumen Group was formed. This group will study the production, testing and utilisation of asphaltic bitumen from all aspects other than those which pertain to civil and highway engineering.

A very successful conversazione was held in November to mark the official inauguration of the new constitution. Mr. G. W. Lepper, of H.M. Petroleum Department, lectured on "The Search for Oil in Britain." A small exhibition illustrative of Mr. Lepper's lecture was held at the Institute's premises during November.

The year 1938 has also seen the transfer of the Institute's offices to the new Adelphi building. The Institute occupies pleasant well-lighted offices on the 6th floor. Provision has been made for a large members' room, which also houses the Institute's library and will be used for small informal meetings.

PRELIMINARY work on the production of liquid fuel from peat by the Degviela Industry Co., of Latvia, recently, has made it clear that the economic success of a hydrogenation process would depend upon an annual throughput of 175,000 tons turf (yielding 25,000 tons liquid fuel). A commission to report on the working of similar plants in foreign countries has been sent abroad by the company.

The Pharmaceutical Society of Great Britain

Activities during the Year

THE number of pharmacists on the registers of pharmaceutical chemists and chemists and druggists on December 31, 1937, was 24,211; this was an increase of 1,234 compared with the number on the registers on December 31 of the previous year. The number of premises registered in the register of premises was 15,175 on December 31, 1937, a decrease of 45 on the figure at the previous June.

The twenty-first edition of Volume II of Martindale's Extra Pharmacopœia has just been published, and the twelfth edition of the Pharmaceutical Pocket-Book has also been published during the year.

The demolition of the buildings on the site of the Society's new building in Brunswick Square has been commenced, the contractors being Messrs. Carmichael. It is hoped to transfer the Society's activities to the new building in the autumn of 1940.

During the year the inspectors of the University of London and the Society have made their quinquennial inspection of institutions approved for providing instruction for the Bachelor of Pharmacy degree and the Pharmaceutical Chemist qualifying examination. The approval granted to each institution has been continued.

The first members of council appointed by the Privy Council terminated their period of office during the year. Two of the three members, Sir Humphry Rolleston and Professor James Andrew Gunn, retired, and were made honorary members of the Society in recognition of their services. The two members of council who take their place are Sir Walter Langdon-Brown, M.A., M.D., and Professor Walter James Dilling, M.B., Ch.B.

The draft Poisons (Amendment) Rules, 1938, and the draft Poisons List (Amendment) Order, 1938, have been made by the Home Secretary, and, if confirmed without amendment, will come into operation on and from January 1, 1939. The rules incorporate a number of suggestions made by the Council of the Society to the Poisons Board for amending the labelling provisions. The Society, as one of the authorities responsible for the administration of the Pharmacy and Poisons Act, 1933, had found that a number of the labelling provisions of the Poisons Rules, 1935, could not be complied with in practice.

The British Pharmaceutical Conference held its seventy-fifth annual meeting at Edinburgh, the chairman's address by Mr. J. Rutherford Hill being entitled "The Pharmacist and the National Health Services." Contributions included papers on phases of pharmacy in Edinburgh, the vacuum drying of extracts, and the enzyme papain and its value in the preparation of some pharmaceutical products.

THE first year of trading of the Belgian concern, the Soc. Belge de l'Azote et de Produits Chimiques de Marly resulted in a gross profit of 54.6 million francs and a net profit of 22.2 million francs out of which a dividend of 6 per cent. is being distributed.

Society of Public Analysts and Other Analytical Chemists

A Year of Progress in all Activities

THE past year has been one of progress for the Society of Public Analysts and Other Analytical Chemists in all its activities. Membership has increased and now exceeds 860, meetings have been well attended, the financial position is sound, and the Society's journal *The Analyst,* has grown both in size and in circulation. More than 50 original papers on analytical subjects have been published in this journal in the course of the year, and about 30 original analytical notes; of the former about one-third, and of the latter about one-half, deal with inorganic analysis.

Following the established precedent of biennial presidential terms of office, Dr. G. Roche Lynch retired from the presidency in March, and was succeeded by Professor W. H. Roberts, public analyst for Liverpool and various other Western districts. In March, also, the Society celebrated its 64th anniversary by a dinner held at the Royal Palace Hotel and attended by a number of distinguished guests.

Seven meetings at which papers have been read and discussed have been held in London, one of them in conjunction with the Food Group of the Society of Chemical Industry. Meetings elsewhere have also been held by the two branch sections of the Society, namely, the North of England Section under the chairmanship of Professor T. P. Hilditch, and the Scottish Section under the chairmanship of Dr. J. F. Tocher. The summer meeting of the North of England Section, organised as a week-end social gathering at Scarborough in June, was a memorable pleasure to all those who were fortunate enough to attend it.

The Food and Drugs Bill introduced into Parliament by the Government early in the year concerned many members of the Society very closely. It was scrutinised in council and in committee, and considered clause by clause at a special meeting of the public analyst and official agricultural analyst members of the Society, and a number of comments and suggested modifications were submitted to the Ministry of Health. At a later stage representatives of the Society gave evidence before a Joint Committee of the Houses of Parliament, and in these and other ways the Society succeeded in getting important emendations embodied in the Bill before this became an Act.

The Biochemical Society in 1938

Sir Arthur Harden's Retirement from Editorship of the "Biochemical Journal"

THE Biochemical Society has held eight meetings during the past year, at the following places:—Lister Institute of Preventive Medicine; Wellcome Chemical Research Laboratories, London; Department of Biochemistry, University College, London; Department of Biochemistry, University of Oxford; Department of Medical Chemistry, University of Edinburgh; Biochemical Laboratory, Cambridge; Department of Pathological Chemistry, University College Hospital Medical School, London; and Laboratories of J. Lyons and Co., Ltd., London. All these meetings were well attended and a total of 71 papers was read. The pre-circulation of abstracts of papers to be read at the Society's meetings, which was begun last year, has been satisfactorily continued.

At the annual general meeting of the Society, held at University College, London, in March, a presentation was made to Sir Arthur Harden on the occasion of his retirement from the editorship of the *Biochemical Journal* after 25 years' service. The presentation took the form of an inscribed salver, bearing the signatures of those still living who have served on the committee of the Society during Sir Arthur's tenure of the editorship of the Journal. In making the presentation on behalf of the Society, Professor H. J. Channon, chairman of the committee, drew attention to the enormous growth of the *Biochemical Journal* which has occurred during the past 25 years. The average number of words published annually has increased from 180,000 to 1,500,000 during this period.

At a meeting of the Society held at University College Hospital Medical School during November, Sir Arthur Harden was elected an honorary member of the Society. Sir Arthur is the Society's only honorary member, and is only the second person to have been thus honoured.

During the summer, Professor H. Raistrick, F.R.S., tendered his resignation from the joint secretaryship of the Society after having served continuously since 1930. The Society's gratitude is due to Professor Raistrick for his valuable services during a very important period of the Society's development.

Society of Glass Technology

A Review of Activities during 1938

THE concluding functions in connection with the Society's 21st anniversary celebrations took place in January; they included the delivery of a series of special lectures dealing with "Glass in Modern Life," and the exhibition of films. The celebrations included a visit to the glass works at Wealdstone of James Powell and Sons (Whitefriars), Ltd. This visit was noteworthy by the fact that the first visit paid by the Society in London was in 1917 to the old works of Messrs. Powell at Whitefriars. To commemorate the occasion Messrs. Powell presented an engraved goblet to the Society.

Of the other meetings held during the year, the most important were those at Droitwich in May, when the Fifth Glass Convention was held. In this gathering the Society of Glass Technology co-operated with the Glass Manufacturers' Federation. The Fifth Glass Convention would normally have been held in 1937, but was postponed to 1938 in view of the International Congress on Glass held in England in 1936 and the Coronation in 1937. At the Droitwich Convention, Mr. H. S. Williams-Thomas, of Stourbridge, succeeded Mr. Geoffrey L. Pilkington, of St. Helens, as convention president. The subjects discussed at the convention were (a) craftsmanship in industry, (b) recent industrial legislation, (c) plastics and their relation to the glass industry, and (d) industry and the trade cycle. A full report of the convention proceedings was published in the August issue of the Society's "Journal," which was published bi-monthly during the year.

At the annual general meeting in April, Dr. C. J. Peddle, of Forster's Glass Co., Ltd., St. Helens, was elected President in succession to Professor W. E. S. Turner, who reverted to his former office of honorary secretary.

During the year the three local sections of the Society (London, Midlands and Yorkshire) maintained their activities. Meetings of these sections are held in the evenings in contrast to those of the parent Society which are usually held in the afternoon. That these local sections do meet a need is evidenced by the fact that 177 persons attended the October meeting which was held at the works of the Rockware Glass Syndicate, Ltd., Greenford.

Towards the end of the year the Society made preliminary preparations to participate in the International Congress on Glass to be held in Berlin and Munich in July, 1939.

A NEW type of zinc sulphide pigment, claimed to have high covering power has been brought out in the United States by the New Jersey Zinc Co. The pigment is prepared by the action of an excess of hydrogen sulphide on an aqueous solution of zinc sulphate containing 30 grams zinc sulphate per litre. The excess of hydrogen sulphide recommended is obtained by using gas containing at least 50 per cent. H_2S in a proportion of 25 times its volume of the solution. The reaction is carried out by passing the gas and the liquid in counter-current through a series of vats connected by venturi tubes.

Review of Chemical Engineering for 1938

By

W. C. PECK, M.Sc., M.I.Chem.E., M.I.E.C., A.I.C.

IT is perhaps more than coincidence that in 1938, when the organisation of the physical fitness of the nation was a prominent feature of governmental activity, chemical engineering for the year should be concerned with subjects associated with national health. In a thoughtful article Hinchley, of grateful memory, in 1930 drew the attention of chemical engineers to the demands of improved conditions of leisure and comfort, and instanced the abolition of pollution of air and water resulting from industrial effluents, as a primary requirement.

Hinchley had in mind the demands of democracies of the period for improved conditions of leisure and comfort. With the mechanisation of industry and the inevitable monotonous characterless robot-like type of work the importance of leisure was uppermost, but it is questionable whether workers in industry put to some monotonous task, and then exercised and amused, will want to continue working at the monotonous task. Democracies in those days stressed too strongly their rights, and overlooked their obligations. To-day the philosophy of the totalitarian States, with their insistence on the obligations of the individual to the State, and their re-orientation of values of work and leisure (and the violent crisis resulting in September) is causing the democracies to reconsider their scale of values. Work in order to achieve leisure will never be so satisfactory a philosophy as work with a definite objective in view, with its resulting satisfaction from achievement. The importance of national health for both work and leisure, has resulted in the acceptance of the obligation of industry not to pollute the air and water, by effluents. During the year we find published papers on effluent disposal for the avoidance of river pollution; on the treatment of gaseous effluents from furnaces, for removal of solid and gaseous impurities, and also a paper of first rate importance on the isolation of vitamin A, an essential accessory to diet, by a new technique termed molecular distillation.

Effluent Treatment

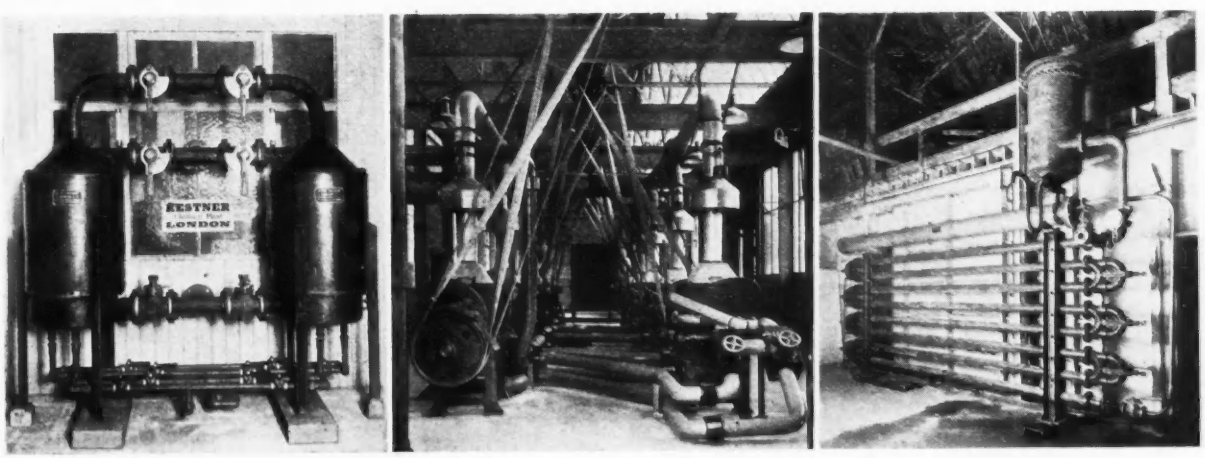
The paper by Bush before the Institution of Chemical Engineers on the electrical precipitation of dusts showed that in the cement industry a large proportion of works were using electrical equipment for arresting dust from gas discharged to the atmosphere. The cleaning of gases from dust and moisture from furnaces and kilns was now more widely adopted, more especially where those gases were used in an industrial process because of resulting economies, but not so consistently where the gases were discharged to air.

The development of a process of flue gas washing without effluent was the subject of a paper by Lessing (*J.S.C.I.*, 1938, 374). The process was developed at the Fulham power station because the Electricity Commissioners attached to the consent for the erection of the station a condition that sulphur, smoke and grit should not be emitted from the chimneys, and pollution of the Thames also had to be avoided because of the magnitude of the operations. Complete elimination of sulphur dioxide was possible by washing the flue gases with a lime or chalk suspension, but demonstrated the serious risk of blockages by calcium sulphate ($CaSO_4 \cdot 2H_2O$) scale, due to supersaturation of the washing solution. Rapid de-supersaturation was brought about by the use of solid $CaSO_4 \cdot 2H_2O$ in suspension.

A paper by Samuel, before the Institution of Chemical Engineers, dealt with aspects of flocculation in the treatment and disposal of effluents for the avoidance of pollution of rivers and streams by coal washery, pulp and milk plants.

Molecular Distillation

Molecular distillation, after being of interest to chemists for the past nine years and now become a commercial operation, was the subject of a group of papers before the Chemical Engineering Group of the Society of Chemical Industry. It is characterised by the use of permanent gas pressures so low (10^{-6} atmospheres) as to play no essential part in determining the speed of distillation. In order to obtain a reasonable rate of distillation a cooled condensing surface is supported a few cm. above a shallow heated pool of liquid, the whole being enclosed in an evacuable chamber. It is necessary to exhaust the still to the extent that the majority of distillate molecules do not collide with gas molecules in their path from evaporating to condensing surfaces. That is, the gas pressure must be so low that the mean free path of the distillate molecule in the residual gas is of the same order or greater than the distance between the evaporating and condensing surfaces. There is no well-defined temperature at which distillation begins. It is of great importance to avoid foaming to degas the feed in high vacuum before passing it to the evaporating tubes. A still has been built which produces



Examples of new plant developed during the past year by the Kestner Evaporator and Engineering Co., Ltd. Left: silica gel air drying plant with double absorber for continuous operation. The interesting feature of this plant is that re-generation is carried out without steam. Centre: a battery of jacketted mixers for bitumen and other compounds heated by the Kestner Merilene system. Right: a Kestner horizontal film type evaporator with a special superimposed cast iron separator.

four tons of distillate per day when working at a vacuum of 1μ. The process has the advantages of (1) about 100° Centigrade lower distillation temperature than normal vacuum distillations, and (2) short length of heat treatment.

While the thermal efficiency of the process is low and the process has only a limited fractionating power, it is important for the treatment of thermally labile substances. Thus it has been used in the purification of crude oils from fatty acids and phosphatides, etc., and in the isolation of vitamin A from liver oils, in which the amount is very low. The scale of operation with fish liver oils is of the order of ½ ton per day.

Heavy Chemical Industry

The markets for heavy chemicals after a promising opening were on the quiet side and business was lower than expected. There was an increase in October, but this was usual and normal so that on the whole there was not much activity in the opening of new plants. A new contact sulphuric acid plant was built for F. W. Berk and Co., of West Ham, and



An extraction plant for the removal of delicate essential oils from vegetable material made by W. J. Fraser and Co., Ltd. Either alcohol or trichlorethylene can be used for the solvent, the water separator being arranged accordingly.

is another instance of the advantages of compact plants occupying small space and capable of great flexibility in operating economically at various outputs. The new plant operates on the catalyst system using sulphur as raw material. The vanadium catalyst is employed which is more robust than other catalysts, no special purification of the sulphur dioxide being necessary as impurities do not have a poisoning effect. The new plant incorporated the newest developments in chemical engineering, such as removal of dust and moisture from the gases and air, and the use of iron-free bricks and rings in drying tower construction to give high quality acid. The operating conditions are under careful and centralised control in a tiled laboratory having instruments mounted on one panel. The erection of the plant is evidence of the supremacy of the vanadium catalyst in spite of improvements in the platinum catalyst process.

Corrosion resisting and special steels.—The metallurgist continues to provide an increasing supply of new metals and alloys with increased mechanical and corrosion resistant properties. The acid resisting steels, of the austentic 18.8 chromium nickel type, together with the modifications produced by the addition of small percentages of other metals, *e.g.*, titanium, molybdenum and tungsten, for corrosion resistance to special conditions, are being adopted more extensively, though the supply of these metals in fabricated forms is still sluggish.

The subject of special steels having heat resisting properties is of increasing interest and may be approached from two angles; the resistance of the steel to oxidation and scaling and its resistance to "creep" under prolonged loading at elevated temperatures. The addition of chromium imparts to steel greatly improved scaling resistance as compared with ordinary carbon and alloy steels. The addition of nickel and chromium in considerable proportions imparts a changed internal structure, resulting in the class known as austentic steels, and develops, in addition to resistance to scaling, a considerable increase in strength and resistance to "creep" at high temperatures. At the highest working temperatures resistance to "creep" is further improved by the addition of tungsten.

Nickel.—Monel metal, nickel, nickel clad steel, and also stainless steel clad steel are being used to meet the special requirements of an increasing number of processes.

Hastelloy, an alloy containing 58 per cent. of nickel, 20 per cent. molybdenum, and 20 per cent. iron, with the addition of small amounts of chromium and silicon in special cases, is of interest because of its resistance to hydrochloric acid. It is available in practically every form, castings, wrought parts, rolled sheets and welded tubing. It is readily machinable, makes excellent casting and can be welded by either the oxy-acetylene or the electric-arc process. The alloy withstands the action of hydrochloric acid in all concentrations at temperatures up to 70° C.; sulphuric acid at all concentrations up to 50 per cent. up to the boiling point, and is one of the few metallic materials possessing adequate resistance to hypochlorites and other solutions containing free chlorine in appreciable concentrations, such as those used for bleaching purposes. The costliness of the alloy, however, prevents its more ready adoption, but its usefulness is apparent.

The world consumption of nickel in cast iron increased more than 30 per cent. during 1937, establishing a new high mark. This is evidence of the usefulness of such alloys as Ni-Resist (14 per cent. Ni, 6 per cent. Cu, 2 per cent. C.) which have, in addition to good chemical resistance, good wearing and heat resistance characteristics, the latter showing no appreciable alteration up to 1,000° C. The use of nickel alloyed cast iron is extending in the oil refining industry for pumps handling acid sludges; in the chemical and allied industries for corrosion resistance in the manufacture of phosphoric acid, fertiliser and phosphate, and also in the production of caustics, soap and salt. In the cement industry Ni-Resist is used in the construction of grinding mills.

The food industry is using increased quantities for the structural parts of food processing machinery, while the paper making industry makes use of alloyed cast irons containing nickel and silicon.

Lead.—Lead for use in chemical plant construction was the subject of a paper by Jones, in *Chemistry and Industry*, 57, No. 8, 251. In plant construction the lead used is of a high degree of purity, and in rolled extruded and cast forms it is applied in such plant as sulphuric acid chambers, towers, heating and cooling coils, tank linings, and ammonia saturators. In such circumstances long life is customary and appears to be governed by resistance to corrosion alone. Thus the physical properties of the lead appear to be of secondary interest, and so there is little need for modifications of those

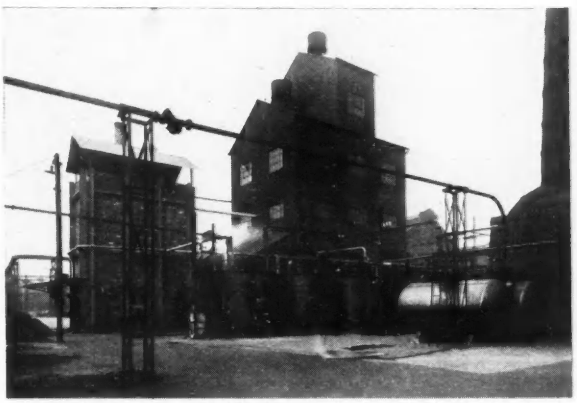
properties. In other cases, however, failure by corrosion is preceded by mechanical breakdown; the continued cycles of heating and cooling sometimes cause final failures through distortion and buckling, and sometimes actual fatigue. Like all ductile metals lead will fail by fatigue cracking under severe vibration, and knowledge of mechanical and crystallographic properties of lead is important. Fine grain structure has been established as necessary for the maximum corrosion resistance. Jones showed that additions to lead of copper of the order of 0.06 per cent. inhibit grain growth and increase fatigue strength. Tellurium exerts a pronounced effect on the physical properties of lead, and in the proportion of 0.05 per cent., about the maximum amount that can be uniformly alloyed, increases the toughness and fatigue strength of rolled and extruded lead. Unlike pure lead, spontaneous annealing and recrystallisation do not occur in tellurium lead during cold rolling and the material consequently work hardens intensely. In the severely cold work condition, tellurium lead sheet is much too stiff for convenient manipulation and so is softened by annealing at 200° C. This prevents a partial recrystallisation and leaves the alloy in a tough fine-grained condition. This structure, as would be expected, is extremely stable and resists grain growth even after straining and prolonged heat treatment. Under conditions of temperature fluctuations, tellurium lead sheets resist buckling and fracture more than ordinary lead. In corrosion resistant structures fabricated by welding it is always desirable that the properties of the weld metal resemble those of the sheet, and it has been shown that the addition of copper to tellurium lead in excess of 0.6 per cent. is beneficial in that it prevents the formation of coarse crystalline structures during welding.

Super-Purity Aluminium

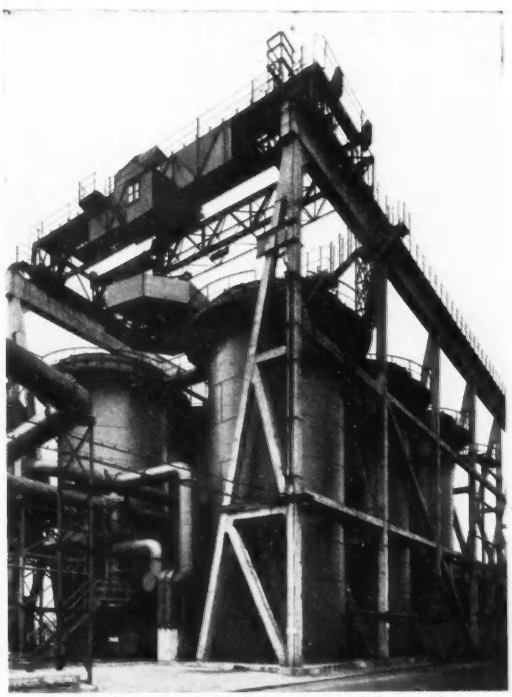
Aluminium.—The purities of aluminium commonly used in the chemical industry are 99.5 per cent. and 99.8 per cent. In addition it is now commercially possible to refine aluminium to 99.99 per cent. purity. The behaviour of this super-purity or "S.P." metal is so different to the behaviour of the highest purities produced by the normal process, that it can be regarded as a new material. This new quality has been found satisfactory for use in certain conditions where the normal high purity grades of aluuminium give insufficient life. In certain cases alloys of aluminium are of more use than the metal itself. Thus alaminium-copper and aluminium-silicon alloys have given very satisfactory results in the handling of fatty acids and in contact with mercury and mercury salts, and such developments are pointers to future work along the line of corrosion resistance.

The improvement in mechanical properties without influencing the corrosion properties has been achieved by the addition of 1¼ per cent. of manganese to aluminium. The largest recorded fabricated aluminium vessel built recently is a rotary vacuum steam jacketed dryer, used for the drying of a heat sensitive chemical. The dryer, 5 ft. diameter and 32 ft. long, with an inner shell made of one inch thick welded aluminium, required a new welding and fabricating technique. To overcome any possibility of contamination, specially designed stuffing boxes were necessary to prevent oil from reaching the material. The bearings were of outboard type bronze brushed with oil wipers to prevent oil following the shaft. Additional heating surface was provided by aluminium tubes attached to the steam heated stainless steel agitator. Because of the very close clearance required between the agitator and the shell, special arrangements were necessary to secure even heating and prevent unequal expansion and contraction.

The rubber-like synthetics continue to receive increased attention. This is because they have marked superiority over natural rubber in resistance to oil, and to ozone and sunlight. Products are now available manufactured with special attention to characteristics such as resistance to abrasion, resistance to temperature, and little swelling in contact with oils and solvents. The principal synthetic rubber is Neoprene, developed by the Du Pont Co. from the work of Nieuwland on the condensation products of acetylene with a cuprous chloride-ammonium chloride catalyst. Supplies, temporarily held up by the fire at the Du Pont plant, have been normal since June of this year. Neoprene is being adopted for linings of reaction vessels, and for centrifugal baskets, and cements have been developed for the bonding of the material to metal.



A continuous tar distillation unit installed at the Port Clarence works of Dorman Long and Co., Ltd., by the Chemical Engineering and Wilton's Patent Furnace Co., Ltd. The plant, which was put into operation early this year, has an output of 85 tons per day. The plant embodies the Wilton patent pipe still high turbulence recirculation system and only requires one operator per shift.



(By courtesy of Mr. C. M. Croft, Chief Engineer and General Manager of the Wandsworth and District Gas Co.)

Tower type purifiers constructed by W. C. Holmes and Co., Ltd., and put into operation this year at the Fairfield works of the Wandsworth and District Gas Co. These purifiers are the first of their type to be built in England and are constructed under licence from Bamag-Meguin A-G. under the Thyssen-Lenze patents. The tower purifiers are for the purpose of removing hydrogen sulphide from town's gas, using iron oxide, and the plant is capable of dealing with 10½ million cubic feet daily. The principal advantages of the system are the greatly reduced ground space required compared with normal box type purifiers, and the very considerable saving in labour charges for emptying and refilling the boxes.



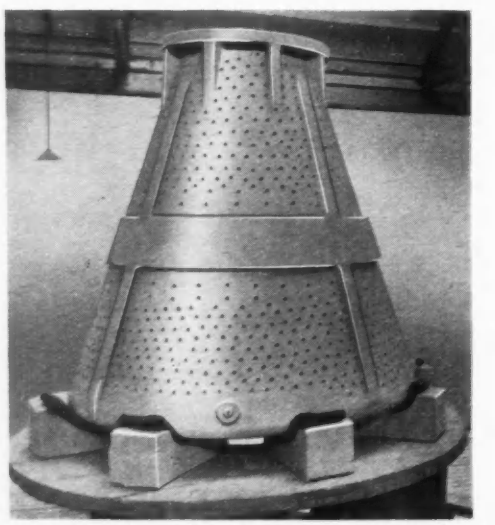
Examples of lead coated work made by the Oxley Engineering Co., Ltd. Left: a mild steel basket, 5 ft. dia., ⅛ in. thick with three supports 2½ in. by ⅝ in. flat, completely covered with sheet lead ¼ in. thick. Centre: a mild steel lid, 6 ft. dia., in process of coating homogeneously with lead 5/16 in. thick. Right: a mild steel conical bottom for benzol washer, 8 ft. 2 in. dia., by 2 ft. 6 in. deep, homogeneously lead lined inside 3/16 in. thick.

The adoption of a new system of fabrication whereby the jacket of a vessel is swaged and welded in a number of places to the inner vessel, should result in economies in plant cost because the outer jacket can then assist in carrying the load on the inner vessel. As the inner vessel is usually constructed of special metals, stainless steels, etc., this should result in lowering the cost of special metal used and should eventually aid the adoption of special metal construction. There are advantages arising from the absence of rivets, and their tendency to leak, so that the steam shelves for vacuum ovens now constructed on a similar principle, and having internal baffles to direct the heating medium, are much preferred.

Unit Processes

The unit processes of chemical engineering are now universally recognised, but the term of great use in its early conception, is being realised to be ambiguous, as it implies that the process is a fundamental one. In many unit processes, there is more than one basic principle operating and a consideration and careful balancing of all the basic principles is necessary for successful plant design. Thus crystallisation plants cannot be designed from a consideration of heat transfer alone, because a surface factor controlling the crystallising or "material transfer" rate also plays a part, and a balance between cooling and crystallising rates must be preserved for any successful plant design.

Gas absorption in many cases can be shown to be dependent upon two principles, absorption proper and heat abstraction. The balancing of the rate of the heat transfer with absorption rate for hydrochloric acid has been shown to be essential for successful plant design in a recent paper in the *Industrial Chemist* (November, 1938). Extraction or leaching, another unit process, is now regarded as a diffusion or material transfer process followed by a separation process.



A stoneware perforated rotating drum in course of manufacture in the drying room at the Erith works of Doulton and Co., Ltd. This drum is over 5 feet high and is an interesting example of the possibilities of stoneware as a chemical engineering material. Drums such as this are used for automatically pickling light castings, etc., and very exacting demands are made on the material, both from the point of view of acid resistance and mechanical strength.

Multiple-Purpose Plants

The analysis of unit operation into more basic principles has resulted in the construction of plants with multiple uses,



A photograph of some of the largest Vitreosil fused silica pipes now being made by the Thermal Syndicate Ltd. They are 10 ft. long by 6 in. bore and were supplied to a recent foreign order.

i.e., built to carry out several unit processes. Thus plants of the type of ball or pebble mills are built with heating and cooling jackets so that in addition to the normal grinding and mixing carried out, processing of the materials by heating or cooling under pressure or vacuum is also accomplished. Vacuum rotary dryers are now constructed which combine several operations, such as mixing, distilling, drying and sometimes grinding, or extracting and solvent recovery. In those types of plants the common factor of each unit operation carried out is heat transfer.

Compressing as a Unit Operation

Tabletting formerly limited to few uses is finding an increasing number of applications in chemical, electrical, food and industrial fields, and the process is being rapidly extended to many new materials and purposes. The process and use of automatic machines speeds up production, facilitates preliminary handling and final use, often greatly reduces manufacturing costs, and usually produces more uniform products. In the ceramic industry, dry compressing of electrical porcelain parts is replacing hand and wet moulded pieces with important savings in time, machinery and finishing, and with increased uniformity and reduction of shrinkage.

A wide range of shapes are now compressed from clay,

(*Continued on page* 532.)



A. O. Bentley.

Progress in Synthetic Drugs and Pharmaceuticals

By

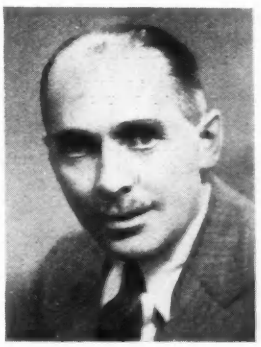
A. O. BENTLEY, Ph.C.

(Reader in Pharmaceutics in the University College of Nottingham)

and

D. H. S. COX, M.P.S.

(Chief Pharmacist to the Nottingham City Hospital)



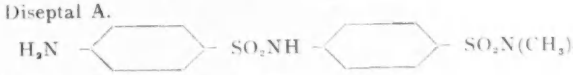
D. H. S. Cox.

THE year has been marked by the introduction of a number of new compounds, the value of all of which, however, has not been fully attested. It would probably be true to say that the most important advances have been made through the development of the streptocidal agents and their application to staphylococcal and other infections.

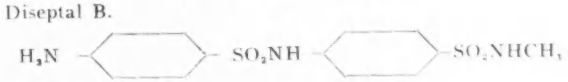
Streptocidal Agents

Much research has been done during the past year with the object of discovering a substance which, while possessing the lowest possible toxicity, will influence the greatest number of bacterial diseases in addition to the streptococcal infections. While the sulphonamide group of compounds, introduced in 1937, had a highly specific action on streptococci, the need for a similarly effective chemotherapeutic substance against staphylococcal organisms became doubly evident, and prolonged clinical trials on certain substances, differing only by the various substitutions in the original sulphonamide group, have shown that these new compounds, while retaining their streptococcal activity, have an effective action on staphylococcal, gonococcal, and gas-gangrene organisms. Three such compounds which have undergone considerable clinical trial on the Continent during the past two years, are Diseptal A, B, and C. Though differing only slightly in composition the three compounds were found to have varying degrees of bacteriostatic action.

Diseptal A.



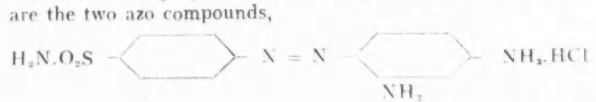
Diseptal B.



Diseptal C.

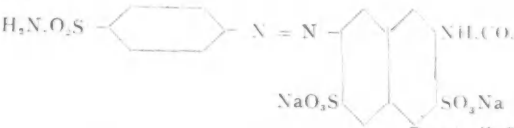


Investigations by Dogmak and his co-workers, extending over two years, have shown that while all three preparations are approximately equally effective in streptococcal infections in mice, they have proved markedly superior to the original sulphonamide compounds in staphylococcal and gas gangrene (*B. Fraenkel*) infections. In the latter instance the dimethylamide and the monomethylamide were similar and better than the non-methylated amide. In gonococcal infections the best results were obtained with the dimethylamide. This compound 4—(4-amino-benzol-sulphonamide)—benzol-sulphon-dimethylamide has now been introduced into this country under the name Uleron. A point of considerable interest concerning this compound is its mode of action; it is not one of the preparations which splits up in the body, as are the two azo compounds,



Prontosil Red.

and



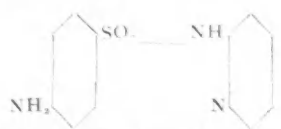
Prontosil Soluble.

It was originally believed that these azo compounds had first to be reduced to the para-amino-phenyl sulphonamide (sulphanilamide) in order to be effective, and this point of view was supported by the findings of English investigators. Further research showed that large quantities of the sulphonamide-azo compounds are split up in the body into sulphanilamide and its derivatives, and some workers considered that the coloured Prontosils acted only by virtue of the sulphanilamide that they yielded. This is not now generally believed, and the fact that Uleron has an action against organisms similar to those which are susceptible to the sulphonamide-azo compounds is one of the reasons against the belief stated above.

Mode of Action of Sulphonamide Derivatives

The excretion and conversion of the colourless sulphonamide, Prontosil album, para-amino-benzene sulphonamide, in the body has also been studied by Marshall, Cutting and Emerson, who found that a large proportion of the drug was acetylised before excretion. In the case of Uleron too, the only product of excretion is its acetyl compound which is present in large quantities in the urine. Since, however, the acetyl compounds of both Prontosil album and Uleron are considerably less effective on streptococci than the acetyl-free compounds, too much reliance should not be placed on conclusions about the mode of action from the isolated products of excretion. Furthermore, since up to 95 per cent. of the sulphonamide administered is excreted as such or in its acetylised form, no noteworthy quantities are retained in the body to form chemical compounds.

Although the sulphonamide compounds are so effective in the treatment of streptococcal infections generally, they are much less active against the pneumococcus than they are against the hæmolytic streptococcus, and in spite of the fact that many compounds allied to, or derived from sulphonamide have been examined, those which were active against the pneumococcus were either insufficiently so, or were too toxic to be considered worthy of clinical trial. An important exception, however, was one which bore the experimental number M & B 693, by which name the product is now known. This substance is related both to sulphanilic acid and to aminopyridine, and is 2-sulphanilyl-aminopyridine.



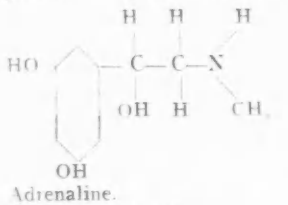
It was found, as a result of a series of investigations carried out by Whitby and his assistants, to have a high anti-

pneumococcal activity on mice inoculated with virulent strains of pneumococci, and its therapeutic activity, as indicated by the ratio between its activity and its toxicity, was considered sufficiently high to justify its clinical trial in acute lobar pneumonia in human beings. Evans and Gaisford (*Lancet*, July, 1938) recorded their findings in a hundred cases of lobar pneumonia observed simultaneously with an equal number of comparable cases serving as controls and receiving non-specific treatment. The case mortality rate was 8 per cent. as compared with 27 per cent. for the control series observed at the same time. The mode of action of M & B 693 is, as yet, imperfectly understood, but it is at present presumed to exercise a direct bacteriostatic action on the pneumococcus, coupled with the production of degenerative changes therein, which are followed by leucocytic destruction of the micro-organisms.

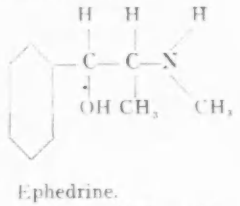
A New Pressor Drug

Several drugs have been introduced during recent years that are chemically related to adrenaline and acetylcholine, and one very noticeable characteristic of this type of compound is the way in which they reproduce mainly one action of their parent substance. Carbaminoylcholine chloride (the urethane of choline), and acetyl-β-methylcholine chloride, are two instances of this class, while benzedrine (β-phenylisopropylamine sulphate), with its remarkable cerebral effects, is another example of this new group.

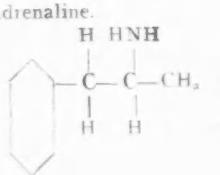
The preparation, Ciba 2020, a sympathomimetic drug, is a distant relation of adrenaline. Its chemical composition is trimethoxybenzyl-dihydroimidoazol hydrochloride, and the relationship between adrenaline, 2020 and other related compounds can be seen from their structional formulae.



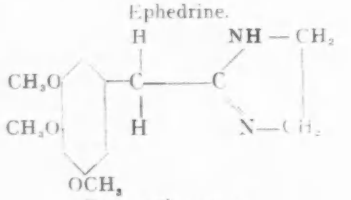
Adrenaline.



Ephedrine.



Benzedrine.

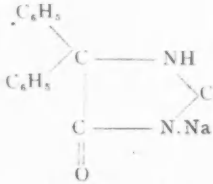


Preparation 2020.

Clinical trials have shown that injection of Preparation 2020 produces a rapid rise of the blood pressure which is followed by a lowered pulse rate, though this latter effect is prevented or abolished by atropine, without loss of the pressor effect. It has been found helpful in controlling the blood pressure during spinal anaesthesia and in the treatment of operative shock. Its action on the bronchial musculature renders it of some value in asthma, but it appears to be inferior to ephedrine, though it may be useful as an alternative drug when ephedrine is contra-indicated or inactive.

An Anti-Convulsant

Putnam and Merritt developed a standardised method of causing convulsions in experimental animals, the significant feature of the method being that it permitted quantitative determination of the "convulsion threshold." Using this method these workers studied the anti-convulsant properties of a large number of drugs, including phenyl, cresyl, and tolyl sulphonates; benzoates; ketones; esters of carbamic and malic acids; barbituric acids; and hydantoins. It was found that diphenyl hydantoin was most prominent among the compounds that possessed greatest anti-convulsant activity, and that this drug was as effective as phenobarbitone in raising the threshold to experimentally produced convulsions in cats and that it produced considerably less narcosis. The soluble sodium salt of diphenyl hydantoin (Epanutin) was found more practical for clinical use than the insoluble diphenyl hydantoin itself.



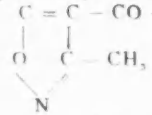
The sodium salt of 5.5-diphenyl hydantoin.

In composition, Epanutin is analogous to the barbiturates, but is a derivative of glycolyl urea instead of malonyl urea. It dissolves in water, leaving a slight precipitate of diphenyl hydantoin formed by hydrolysis of the sodium salt, which precipitate is, however, completely soluble when the alkalinity of the solution is adjusted to *p*H 11.7. Hydrolysis of Epanutin takes place in spite of the fact that it contains the theoretical amount of sodium, because dipenyl hydantoin is an extremely weak acidic substance.

It should be remarked that the drug is not claimed to be a cure for epilepsy, but it will, however, minimise the frequency and extent of convulsive seizures in the great majority of epileptics, whilst being devoid of the hypnotic action of many anti-convulsant substances.

An Analeptic

A new circulatory and respiratory stimulant has been introduced under the name of Cycliton. This compound is the dimethylamide of 3:5 dimethylisoxazol-4-carboxylic acid:

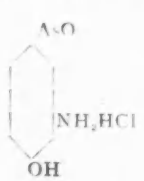


The action of this compound resembles that of camphor, although it is chemically unrelated to it. Cycliton is employed in acute or chronic respiratory diseases and in the prophylaxis of surgical shock. It may be used as a life saving measure in cases of poisoning by gas or hypnotics.

A New Arsenical

Following the injection of arsphenamine there is a period of several hours before a decrease in the number of spirochætes in the blood occurs and it is believed that arsphenamine is not in itself spirochæticidal but that it has to undergo partial oxidation before becoming effectual. Under the name of Mapharside there has been marketed a product which can be produced from arsphenamine by oxidation or converted into arsphenamine by reduction. It is issued mixed with a sufficient amount of alkali and sucrose to make the aqueous solution almost neutral and isotonic with the blood. The aqueous solution on standing becomes less toxic, whereas it is well known that aqueous solutions of some arsenicals become more toxic on standing. Clinical reports speak highly of the new compound in the treatment of syphilis and it has been found to be an effective agent in the treatment of Vincent's disease (trench mouth) when directly applied to the gums.

Mapharside is the hydrochloride of the substance sometimes known as arsenoxide, and has the following structural formula:



Rheumatism and Urinary Diseases

Based upon evidence that both iodine and sulphur in various forms were effective in the treatment of chronic rheumatism, attempts were made to evolve a preparation which would be sufficiently stable on storage, while being

sufficiently unstable to liberate its ions after injection. Under the name of Thionaiodine there has been introduced a mixture of two substances which it is claimed meets these requirements. It is a mixture of stabilised sodium iodide and magnesium tetrathionate, MgS_4O_6, and is prepared in two forms, A, for intramuscular injection, B, for intravenous injection.

An alternative method of attack is exemplified by a new preparation known as Uralysol, which contains thyminic acid, hexamine and the anhydromethylenecitrate of hexamine. Hexamine and its compound are disinfectants of the urinary tract, while thyminic acid is a substance normally present in the blood stream. Thyminic acid has the property of forming a soluble compound with uric acid, and thus is a factor in its elimination from the blood. A deficiency of thyminic acid results in the accumulation of uric acid in the blood stream, in which it is conveyed to various parts of the body there to set up local inflammation.

Mandelic acid has ben used in the treatment of urinary infections for the last two years. It has been used in the form of sodium mandelate, together with ammonium chloride, the function of the chloride being to render the urine acid through the conversion of ammonium ions into urea with liberation of hydrochloric acid. Unfortunately, in some cases the ammonium chloride was found to cause nausea and in others was thought to be responsible for albuminaria. It was found that if the mandelic acid was administered as the ammonium salt, in many instances the collateral administration of ammonium choride was unnecessary. Even so, it still sometimes occurred that nausea or vomiting was produced by the ammonium mandelate. Recently mandelic acid has been issued in the form of its calcium salt, which has been found to be as effective as the other forms. It is tasteless and does not give rise to dyspeptic conditions. On administration mandelic acid is liberated in the stomach and the calcium chloride formed is converted into non-absorbable calcium salts in the intestine. The urine is rendered sufficiently acid by the free mandelic acid, which is ultimately excreted unchanged.

Vitamin B_2

This vitamin had been considered to comprise two factors, (1) lactoflavine, which has been used in the treatment of various forms of anaemia, and (2) an anti-pellagra and anti-dermatitis factor. The second factor in the B_2 complex has come to be known as Vitamin B_6. Further investigation has shown that while B_6 is the anti-dermatitis factor in the B_2 complex it is not the anti-pellagra factor.

It is now thought that the precursor of the anti-pellagra factor is nicotinic acid;

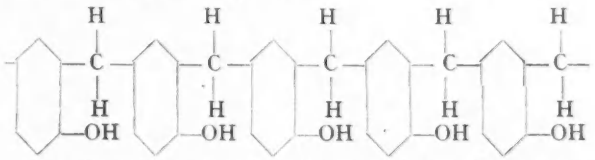


The administration of nicotinic acid or its amide in cases of human pellagra has been followed by excellent results. It is not suggested that the pellagra-preventing factor is itself nicotinic acid but only that the factor is associated with this acid, or derived from it after ingestion, since the effects produced are to some extent dependent on a balanced diet.

New External Applications

The value of coal tar as an application to the skin in cases of infantile eczema, moist eczema, pruritus ani, psoriasis and other skin diseases has for long been well known. Equally well known are the disadvantages of coal tar as an external application, namely, its disagreeable odour, its property of staining clothing and dressings and the fact that when applied to approximating skin surfaces where so many skin complaints originate it is easily rubbed away. Admixture with fatty bases in no way diminishes these disadvantages.

Under the name of Tar Dermament, there has been evolved a preparation which is without the usual disadvantage of coal tar ointments. The base is a polymer of salicyl alcohol or saligenin. Salicyl alcohol polymerises with loss of water to form a resin which is soluble in alcohol and which, on evaporation of the solvent, leaves a film on the skin to which the solution has been applied.



If crude coal tar is contained in the solution the tar is retained in the film and remains in prolonged contact with the area to which the preparation has been applied. The tar cannot stain the clothing and the film not only has analgesic properties but also affords mechanical protection.

A new germicide has been issued under the name of Zant. This is a mixture of para-chlor-metaxylenol with oil of pine and other essential oils. It is stated to be five times as germicidal as phenol when tested by the Reddish modification (*B. coli*) of the Rideal Walker test. It is claimed to be non-irritant and non-toxic. Zant is used in various dilutions for all the usual purposes for which germicides may be required.

Oil and Colour Chemists' Association

The 1937/1938 Season

UNDER the able presidency of Mr. A. J. Gibson, F.C.H., F.L.S., to whom the Association owes much for his work in reorganising its affairs during 1937/1938, the present session has opened very successfully.

In 1937 the decision was taken to sectionalise the Association completely, and the formation of the London Section followed. This step leaves the officers free to give their attention to the general affairs of the Association. Thus, there are now three sections, London, Manchester and Scottish Section and the step necessitated a very thorough revision of the rules. A great effort has been made by each section to provide an interesting and successful 1938/9 session. The programme of all the sections has been co-ordinated and a very interesting collection of papers is in course of being read.

The inaugural meeting of the London Section was held on September 8, when the Chairman, Dr. J. O. Cutter, gave an address. Actually, informal meetings of the section had been held during the 1937/8 session.

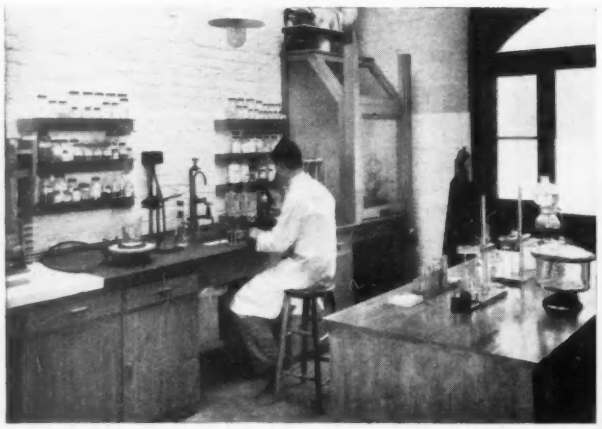
The annual dinner of the Manchester Section was held on Friday, November 4, at the "Manchester Limited." It proved to be the same successful affair expected from experience in previous years. The affairs of the Section are very healthy under the chairmanship of Mr. H. Clayton and the membership continues to grow satisfactorily.

The high light of the Scottish Section's year, their annual dinner and dance, was this year of especial interest. The chief guest was Sir Cecil M. Weir, convener of the Empire Exhibition. The occasion was made memorable by the fact that it occurred during the Empire Exhibition in Glasgow and a large number of visitors were entertained at the Exhibition by the Scottish Section. A lecture which was to have been delivered by Dr. W. Ostwald, postponed on account of the crisis, is to be given in London at a later date. A highly successful year of office is assured to their chairman, Mr. J. Milligan. In March, 1939, the 21st year of the Association is being marked by an anniversary dinner and dance.

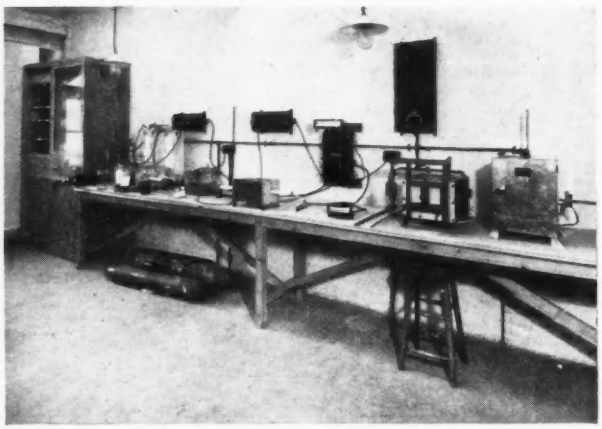
A POROUS mass produced by the Hiag Verein and approved officially as an absorbent material for dissolved acetylene containers consists of a mixture of wood charcoal, kieselguhr, cement and asbestos.

SOME NEW LABORATORIES

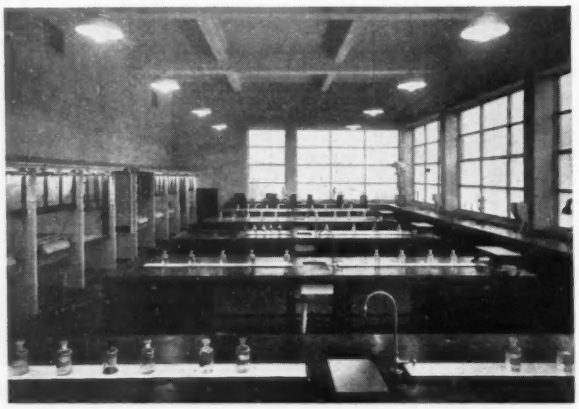
A number of new laboratories have been opened during 1938, a few of which are illustrated below. Outstanding features of these are their modern construction and up-to-date equipment, special attention being paid to lighting and air-conditioning.



A view of the interior of the new chemical research laboratory at the works of Wild-Barfield Electric Furnaces, Ltd., showing part of the analytical bench. The chemical laboratory is one of two sections of a new research department, the other section being devoted to metallurgical testing.

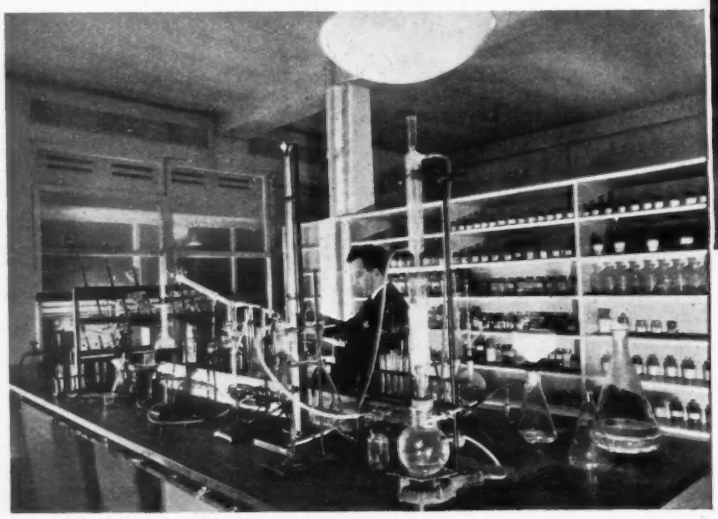


Another view of Wild-Barfield's research laboratory, showing part of the furnace bench which accommodates a number of furnaces of the company's own construction. Among them are a solder bolt heater, a laboratory muffle furnace of rectangular type, and two small tubular muffle furnaces.



The new Admiralty laboratory opened at Sheffield by Sir William Bragg incorporates the latest developments in construction and equipment. Above is a view of the laboratory for analysis of non-ferrous metals and alloys. Here the air conditioning system installed provides eight changes of air per hour.

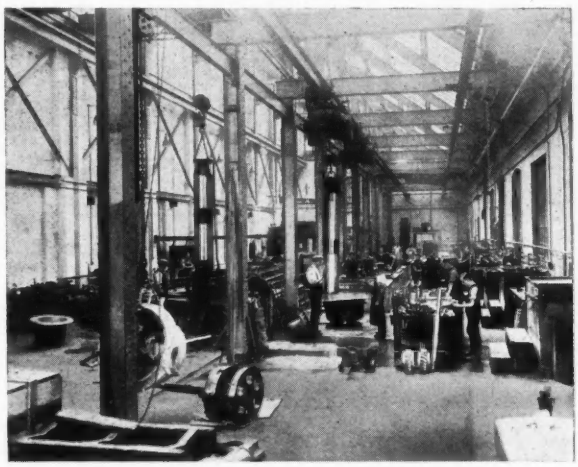




Left : a view of one of the new laboratories built for the Dyestuffs Group of Imperial Chemical Industries Ltd., at Blackley, Manchester. Above : fume cupboards backing on to a main corridor, with part of the panelling removed to show accessibility of the various services (steam, compressed air, vacuum, etc.) The electric motor in the foreground drives the main stirring shaft for all the laboratories on the same floor.

AND WORKS OPENED IN 1938

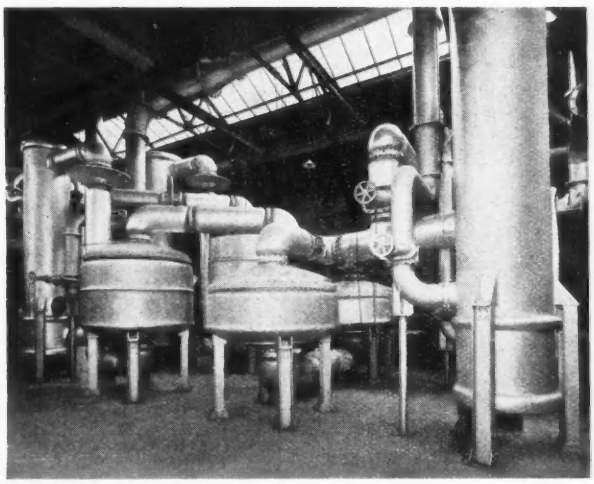
1938 has also seen numerous works extensions and alterations, and below are illustrated the interior of some of the shops and works that have been opened, together with new plant which has been put into operation during the year.



The nickel depositing shop at the new works of Fescol, Ltd. A 6-ton runway travels the whole length of the main bay and is used for loading and unloading heavy goods as well as for handling them in the vats. The vats are constructed of ferro-concrete, lined with acid-resisting material. Shafts up to 20 ft. in length can be handled in the plant.



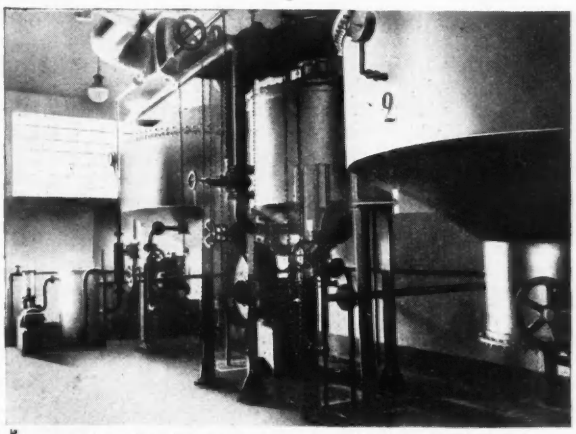
The Chesterfield Tube Co., Ltd., opened a new heavy tube-making plant, described as of a size and power exceeding any other of a similar kind operating in the world. The new plant has been designed for the manufacture of weldless steel tubular products having a maximum external diameter of 54 inches and an approximate finished weight of 16 tons. The illustration shows the horizontal hydraulic tube draw bench, the pierced hollow being positioned on the mandrel bar prior to the drawing operation.



The gas filters, converters and coolers of the new contact sulphuric acid plant at the Abbey Mills chemical works of F. W. Berk and Co., Ltd. The vanadium catalyst developed by the Monsanto Chemical Co., of America is employed. The complete plant was designed and erected by Simon-Carves, Ltd.



Interior view of the new assembly shop at the works of Elliot Brothers (London) Ltd. This building is the largest extension yet made to the company's works and has a floor area of over 24,000 sq. ft.



A two absorber benzene recovery plant by Carbonisation et Charbons Actifs (Acticarbone process; representatives here, Price Stutfield & Co., Ltd.).

Recent Developments in Solvents and Plasticisers

By
ERIC H. BRITTAIN, B.Sc.

IN a year of unparalleled national crisis it is not unnatural that the whole chemical industry throughout the world should suffer a setback from the boom year of 1937. This setback has not perhaps been so marked in the industries making and using solvents and plasticisers and this surely means that under normal international conditions considerable advances would have been recorded. The consumption of ethyl alcohol is always a good index of the state of the solvents industry and this year, compared with 1937, has shown a drop of 6 per cent. both on methylated spirits sales and in alcohol used as the raw material for solvent production. This contrasts with a 27 per cent. gain for 1937 when compared with 1936.

Raw Materials

One important effect of these difficult conditions is the search for new raw materials for solvent production, and it is very striking to notice the efforts undertaken in each country to utilise home-produced raw materials for this purpose. Hitherto unimportant waste products are being worked up for the production of ethyl alcohol, while even the molasses which is still the main source of ethyl alcohol is now obtained as a concentrated syrup containing some 70-80 per cent. sugars made direct from sugar cane juice instead of the 50-60 per cent. by-product from sugar refineries. Incidentally, this change-over has necessitated the use of increased quantities of phosphates and ammonia as nutrients for the yeast during fermentation. Ethyl alcohol is now being manufactured in Eire from potatoes, in Italy from sweet millet and even artichokes, specially grown for the purpose, from sisal juice in Mexico, while in Russia considerable research has been conducted on the recovery of the alcohol normally lost in yeast manufacture. In this last case, however, the aliphatic amines present are somewhat difficult to eliminate. In France the large cereal harvests, together with a severe alcohol shortage, have led to the conversion of large quantities of wheat into ethyl alcohol.

A very large increase has recently taken place in the manufacture of ethyl alcohol by the hydrogenation of acetaldehyde (obtained from acetylene). This process can only be applied where very cheap electric power is available, both for the production of carbide and the hydrogen necessary for the reduction.

The use of ethylene, from petroleum cracking gas, is steadily increasing in the U.S.A., while in Canada it is proposed to crack the ethane in natural gas to ethylene for the same purpose. It is doubtful if the most economic method of converting ethylene to alcohol has yet been worked out, but a recently published process, which seems promising, shows the absorption of ethylene in sulphuric acid under moderately high pressures to give diethyl sulphate, which is distilled off and hydrolysed by steam. This saves the dilution of a large bulk of strong acid liquor and is very similar to a process which has been successfully worked in the U.S.A. for converting propylene to isopropyl alcohol. Diethyl sulphate has recently become commercially available and has proved to be an excellent ethylating agent. It is less toxic than dimethyl sulphate. Boron trifluoride has been suggested as a catalyst for the direct hydration of ethylene by steam. In all such processes the ethylene must be effectively separated from propylene as the latter tends to polymerise to objectionably-smelling hydrocarbons under the reaction conditions necessary for the hydration of ethylene.

Other Alcohols

In addition to the process already mentioned for the manufacture of isopropyl alcohol from propylene, it has been proposed to bring about hydration directly by passing propylene over dilute phosphoric acid, which may contain nickel phosphate in solution, at about 200° C. and pressures between 100-500 atmospheres. It is probable, however, that such processes lead to extensive polymerisation and ether formation. In view of the large quantities of isopropyl alcohol now being manufactured, a recent investigation of the relative toxicity of isopropyl alcohol is of interest, as it shows that there is possible danger of cumulative action in cases of prolonged exposure to its vapours.

So far as the manufacture of methanol is concerned, Great Britain is now completely self-supporting, with a production of about 6,000,000 proof gallons per annum. It is reported that Messrs. Duffield Coal Products are to undertake extensive manufacture of methanol both in Great Britain and in the Colonies.

Butanol, which has for the last twenty years been made by the fermentation of maize, is now being made to an increasing extent by the fermentation of the cheaper raw material, molasses. The U.S. Government have recently financed the erection of an extensive plant in Puerto Rico to manufacture butanol and acetone by this means. The change-over from maize to molasses is also rapidly proceeding in Italy. It is also reported that artichoke juice can be utilised for this fermentation, a yield of 40 per cent. of solvents based on reducing sugars in the juice being obtained. In Germany even the waste liquor from sulphite pulp factories is being used for this purpose.

Although it has been known that ethyl alcohol can be directly converted to butyl alcohol by passage over a catalyst, it has now been found that the yield can be considerably improved by the use of pressures of the order of 50 atmospheres. About 50 per cent. of butanol and 20 per cent. of ethyl acetate can be obtained in this way. Octyl alcohol (boiling point 184° C.) is now available commercially in the U.S.A. and its derivatives should offer an interesting range of high-boiling solvents and plasticisers.

Ether and Ester Solvents

In the field of ether and ester solvents the general trend has been not so much in the development of new solvents as in the modification of the processes used for making well-known products. Isopropyl ether, for example, can now be made successfully direct from propylene without having to pass through the intermediate isopropyl alcohol.

Much experimental investigation has been carried out in Russia on the catalytic conversion of ethyl alcohol to ethyl acetate, the best catalyst so far discovered being a reduced copper-alumina-chromium oxide catalyst. The process, however, leaves much to be desired from the economic point of view. Another method for obtaining ethyl acetate consists of the combination of ethylene with acetic acid. Hitherto this reaction has been found to be extremely difficult to accomplish, but a recent publication claims that by the use of triethyl phosphate as catalyst, satisfactory yields can be obtained. If this claim can be substantiated, it is another example of the modern tendency to use volatile instead of solid catalysts, as triethyl phosphate is now used extensively in the manufacture of acetic anhydride from acetic acid. This last process opens up new fields for ester production, as in the first stage of the reaction ketene is produced and this very reactive substance acts in much the same way as acetic anhydride. Diketene, or cyclobutadione, which is obtained by the spontaneous polymerisation of ketene, reacts with alcohols to give aceto-acetates. It is stated that even cellulose aceto-acetate can be obtained in this way. A very interesting review of the recent advances in the theory and practice of esterification (E. E. Reid, *Ind. Eng. Chem.*, 1937, *29*, 1,344) also stresses the importance of esters in the chemical industry. On reading this paper one cannot but be struck

by the very large number of methods that exist to-day for making esters compared with the two or three available ten years ago.

An interesting proposal in connection with ester solvents is the use of a mixture of amyl acetate and amyl lactate for soaking the adhesive layer in compound glass manufacture. It is claimed that adhesion is much improved in this way.

Ketones

The search for new raw materials has been carried out in the case of acetone, and such outlandish substances as orange peel and shale residues are now being worked up for the manufacture of this product. The production of acetone by the direct hydration of acetylene, which was started last year in Canada is now well established, although the best catalyst for this reaction has probably not yet been determined. It is stated that zinc or manganese vanadates are particularly active catalysts and have a longer effective life than the oxide catalysts used hitherto. The production of acetone in the U.S.A. from isopropyl alcohol is developing rapidly and threatens to render the fermentation method uneconomic in that country. In fact, the almost unlimited supplies of propylene from cracking gases which can be converted to isopropyl alcohol and acetone seem to threaten severe overproducion.

A very interesting review of methyl ethyl ketone (S. L. Langedijk, *Chemistry and Industry*, 1938, *57*, 891) deals with its production from the butylene fraction of cracking gases and its use as a dewaxing agent for lubricating oils. Its most striking property is its high dilution ratio for nitrocellulose and its use in this direction will probably extend very considerably in the near future, especially as it has not the extreme volatility of acetone. It has also been adopted as a denaturant for ethyl alcohol in Italy. Methyl isobutyl ketone (which can be obtained by the hydrogenation of mesityl oxide) has also been suggested as a denaturant.

A number of new higher ketones have become available and these include acetonyl acetone, di-isobutyl ketone, methyl amyl ketone and phorone. In view of the cheapness of ketones and alcohols in the U.S.A., it has been suggested that mixtures of these can be used as solvents or thinners without the more expensive esters.

The chlorinated solvents still continue to be used in industries where fire risks must be reduced to a minimum and among the more recent developments has been the use of dichlorethane as a means of concentrating acetic acid. By distillation in two stages the concentration can be raised from 30 per cent. to 99 per cent. Dichlor-diethyl ether, which is extensively used in the U.S.A. in the solvent dewaxing of lubricating oils, can now, it is claimed, be made by the direct combination of ethylene with hypochlorous acid in the presence of excess ethylene chlorhydrin. The chlorhydrins themselves have been suggested as solvents, particularly for cellulose triacetate, and a process for making bottle caps in this way has been patented. Another series of solvents which have been suggested for this purpose are the lower acetals and formals which are made by the combination of alcohols with acetaldehyde or formaldehyde. Although a number of condensing agents are known for effecting this reaction, it has been found that Twitchell's reagent is well suited for the purpose.

Plasticisers

As has been remarked on previous occasions, the old-established plasticisers still maintain their position in spite of an enormous number of new substances which become available year by year. By far the most extensively used plasticisers are camphor, the alkyl phthalates and lactates, and the aryl phosphates, and their use seems to be extending rather than diminishing. Diethyl phthalate, for example, in conjunction with ethyl alcohol, has been found to render ordinary paper sufficiently transparent for blue-printing. One investigator, who recently undertook a complete investigation of the plasticisers suitable for nitrocellulose films, has found that in concentrations of 10-30 per cent. the best plasticisers were camphor, acetophenone and butyl lactate, while for concentrations up to 10 per cent. the most suitable were the aryl phosphates, butyl phosphate, butyl tartrate and butyl phthalate. Another investigation of cellulose acetate films has shown that the tensile strength rises almost proportionally with the concentration of the plasticiser up to a maximum, which point depends on the particular plasticiser chosen and the acetyl content of the cellulose acetate. With concentrations in excess of this the strength falls very sharply.

The alkyl crotonates have been suggested as plasticisers for cellulose esters. In spite of their unsaturated nature these esters, particularly those of the higher alcohols, are quite stable at ordinary temperatures. They may be brominated and the resulting dibrombutyrates render films completely non-inflammable. Another range of esters are the maleates, which can be readily obtained from the cheaply produced maleic anhydride. The lower alkyl maleates are high-boiling solvents, but the higher alkyl maleates have been found to have excellent plasticising effects.

The recent introduction of the acetone-soluble mixed triesters of cellulose has led to the development of a number of new plasticisers for these substances. The esters of sebacic and adipic acids have, for instance, been found to be excellent plasticisers for cellulose acetate propionate, cellulose acetate butyrate and cellulose acetate stearate, and films formed from these materials are tough, highly flexible and have brilliant transparency and low inflammability. Methyl myristate and methyl ricinoleate have also been found to increase the flexibility of cellulose acetate propionate films. The carbonates of the higher alcohols obtained as by-products in the synthesis of methanol have been suggested as a cheap plasticiser for cellulose derivatives.

The alkyl oxalates have been found to be good gelatinising agents for nitrocotton, although the ease with which they are hydrolysed prevents their being used in dynamite preparations. Esters of tetrahydrofurfuryl alcohol have also been suggested as softeners or gelatinising agents and a particular application is the use of the stearate in lacquers for shoe heels. Among other esters which have been suggested as plasticisers for cellulose derivatives are the dipropionates of di- and tri-ethylene glycols and butyl phthalyl butyl glycollate.

Inorganic Acid Ester Plasticisers

A considerable amount of work on the esters of inorganic acids has been carried out at the Mellon Institute at Pittsburgh. Published results show that tetrabutyl silicate and the silicates of higher alcohols, such as tetradecanol and heptadecanol (both of which are commercially available in the U.S.A.), have promising properties as plasticisers. Nitrocellulose films containing these esters show very good adhesion to glass surfaces. Work on the titanium esters has shown that these may also become important.

A newcomer into the range of film-forming compositions is nitro-starch and suitable plasticisers for this are diacetin, butyl phthalate and diphenyl phosphate. It is said to be particularly suitable as a coating for flexible sheets. Glycol esters and ethers have been found to be of use in modifying the properties of "glyptal" resins. Comparatively few satisfactory plasticisers are known for the polyvinyl resins, such as polystyrene, the polymerised vinyl chlorides and acetates, and the polymerised methacrylates. The phenyl-ethers of glycerol, however, have been claimed for this purpose.

As indicated above, the lower acetals and formals have been found to be satisfactory solvents, while it has also been found that the higher acetals, such as those derived from cyclohexanol and benzyl alcohol have valuable plasticising properties, particularly for cellulose triacetate. Another rather unusual member of this series, the formal of dichlorhydrin, has been found to be useful in the manufacture of bottle caps from cellulose triacetate.

NEWS EVENTS OF 1938

January

The 28th annual exhibition of Scientific Instruments and Apparatus held at the Imperial College of Science and Technology, South Kensington, London, S.W.7, attracted eighty-four exhibitors to the trade section and twenty-six to the research and education section.

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The resignations of Dr. R. J. H. Patijin, Mr. Horatio Ballantyne, Mr. J. W. Pearson and the Marquis of Carisbrooke from their directorships of Lever Brothers and Unilever, Ltd., and Lever Brothers and Unilever N.V. were among the changes announced in the directorships of the Lever group of companies. They were appointed advisory directors and Messrs. H. Davis, J. L. Heyworth and J. P. Van den Bergh were appointed to take their places as members of the board of the English company.

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New laboratories built for the Dyestuffs Group of Imperial Chemical Industries, Ltd., were opened at Blackley, Manchester, by Mr. John Rogers, a director of I.C.I.

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With a view to holding meetings for the study of the general subject of industrial microbiology, the Food Group of the Society of Chemical Industry formed a Microbiological Panel. Professor H. Raistrick and Dr. J. H. Bushill were elected chairman and honorary secretary respectively of the Panel.

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Mr. W. A. S. Calder was elected permanent president of the Midland Chemists' Committee.

February

The following were appointed by the Board of Trade, for a period of three years, to act with the members of the Dyestuffs Advisory Licensing Committee in advising upon the efficient and economical development of the dyemaking industry:—Major J. A. Barber-Lomax, Mr. G. Garnett, Professor A. G. Green, Mr. A. Hittinger, Mr. A. S. Hoskin, Mr. J. R. Lane, Professor Sir Gilbert T. Morgan, Mr. C. S. Robinson and Mr. G. S. Whitham.

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The Falmouth Committee which was appointed by the Minister for the Co-ordination of Defence to consider and examine the various processes for the production of oil from coal and certain other materials indigenous to this country, and to report on their economic possibilities, and on advantages to be obtained by way of security of oil supplies in emergency, issued its report.

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The British Industries Fair, 1938, opened at Olympia and Earl's Court, London, and at Castle Bromwich, Birmingham. The Chemical Section at Olympia was again under the auspices of the Association of British Chemical Manufacturers and was larger in size than the previous year.

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The 16th annual corporate meeting and dinner of the Institution of Chemical Engineers was held at the Hotel Victoria, London, W.C.2, Dr. William Cullen, the president occupying the chair on both occasions.

March

At the annual meeting of the Institute of Chemistry a report submitted by the Council revealed substantial increases in the numerical and financial strength of the Institute. It was stated that the roll of fellows and associates stood at over 7,000 and that the number of members had increased by 217 compared with the previous year.

* * * *

Port Sunlight, the industrial garden city created by the first Viscount Leverhulme, celebrated its golden jubilee.

I.C.I., Ltd., announced important changes in the executive control of the company which involved the functions of sole managing director, previously exercised by Lord McGowan, being taken over by a management board composed of executive and non-executive directors, Lord McGowan acting as chairman of the board.

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The Alkali and Chemical Corporation of India, Ltd., was started under the auspices of Imperial Chemical Industries (India), Ltd., with a capital of Rs 50,000,000 to develop the heavy chemical industry throughout India.

April

The Caledonian Power Bill, which proposed the erection of works for the manufacture of calcium carbide and ferro-alloys at Corpach and Port Talbot respectively was rejected by the House of Commons when it came up for its second reading.

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Sir Henry Sutcliffe Smith, president of the Colour Users' Association and executive director of the Bradford Dyers' Association died at Cannes at the age of 74.

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Mr. Peter F. Bennett was elected president of the Federation of British Industries in succession to Lord Hirst.

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The British Drug Houses, Ltd., instituted a research fellowship at University College Hospital for investigations upon the chemical application of hormone products.

May

The Food (Defence Plans) Department which was set up towards the end of 1936 issued its report in which it was stated that shadow schemes had been drawn up for ensuring an adequate distribution of foodstuffs and for regulating prices. Arrangements were also being made for increasing the home production of wheat, sugar beet and potatoes.

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An announcement was made of a preliminary agreement for an amalgamation between Reckitt & Sons, Ltd., and J. & J. Colman, Ltd.

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At the first annual meeting of the (incorporated) British Chemical Plant Manufacturers' Association, Mr. J. W. Wright, Mr. B. L. Broadbent, and Mr. W. S. Knight were elected chairman, vice-chairman and honorary treasurer respectively.

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When the Rubber Technology Conference was held at the Hotel Victoria, London, W.C.2, under the auspices of the Institution of the Rubber Industry, over 100 papers were presented.

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The International Congress of Chemistry was inaugurated in Rome, the opening meeting being attended by the King of Italy. Various reports and papers were submitted by 2,800 delegates representing 33 nations.

June

Dr. J. W. Mellor, the distinguished scientist and ceramic physicist, former director of the British Refractories Research Association, died.

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Professor William A. Bone, emeritus professor of chemical technology at the Imperial College of Science and Technology, died at the age of 67.

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The 57th annual meeting of the Society of Chemical Industry was held at the Chateau Laurier, Ottawa, Mr. V. G. Bartram (chairman of the Canadian Council) being elected president, Viscount Leverhulme, Professor J. C. Philip, Mr. H. V. Potter and Mr. H. W. Rowell, vice-presidents, and Messrs. H. E. Cox, F. M. Potter, S. Robson, and Professor W. M. Cumming, ordinary members of Council.

Lord Weir, director and member of the management board of I.C.I., Ltd., and a director of the International Nickel Company of Canada, was created a Viscount in the Birthday Honours List and Mr. Louis William Smith, a director of Fison, Packard & Prentice, Ltd., a knight bachelor.

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George Kent, Ltd., the well-known manufacturers of measuring and controlling instruments, celebrated their centenary.

July

New orders and regulations made by the Home Secretary under the Factories Act, 1937, came into force.

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An international agreement concerning the world production of fertilisers was reached, and Mr. F. G. Clavering Fison, representing the industry in this country, visited Holland to sign the agreement.

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An inquiry was opened in London into proposals empowering the Potato Marketing Board to manufacture alcohols and derivatives from potatoes, and also synthetic resins and plastics. Mr. J. Davidson Pratt, general manager of the Association of British Chemical Manufacturers, expressed strenuous opposition to the proposals on behalf of the chemical and plastic industries.

* * * *

Major F. A. Freeth, research manager of Imperial Chemical Industries, Ltd., since the formation of the company in 1926, intimated his intention of retiring from the position, but consented to continue his association with the company in the capacity of consultant.

August

The first substantial consignment of oil from the experimental well struck by the Anglo-American Oil Co. at Dalkeith, Scotland, was transported to Essex for refining.

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Imperial Chemical Industries of Australia and New Zealand, Ltd., commenced constructing a synthetic ammonia plant near Melbourne at a cost of £500,000.

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The annual report of the Chief Inspector of Factories and Workshops for 1937 stated that there had been a notable increase in the number of accidents reported, though the increase was not so great as the previous year.

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Lord Rayleigh delivered his presidential address to the British Association when it met at Cambridge. The presidential address to the Chemistry Section was delivered by Professor Charles S. Gibson, who spoke on recent investigations in the chemistry of gold. A symposium on modern methods of chemical analysis was also held.

* * * *

The retirement of Sir Gilbert T. Morgan from the directorship of the Chemical Research Laboratory, Teddington, a position he had held since 1927, and his appointment as chairman of the Research Fund Committee of the Institute of Brewing, were announced.

September

Brotherton & Co., Ltd., the well-known chemical manufacturers, celebrated their diamond jubilee.

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Though the country was alarmed at the prospect of war during the latter part of September industry remained steadfast and bore the strain with a calmness and self-possession which were the admiration of the world.

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The autumn meeting of the Society of Chemical Industry was held at Glasgow. Most of the business side of the meeting was given over to a symposium on the trend of progress, and consisted of five introductory papers, contributed by members of the Food, Road and Building Materials, Plastics and Chemical Engineering Groups.

Restrictions were imposed on the sale of two new drugs :— Benzedrine and sulphanilamide, under a Home Office order.

October

The first International Fertiliser Congress took place in Rome on the initiative of the International Federation of Technical Agriculturists, with the co-operation of the National Committee for the Use of Fertilisers.

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The largest glass research department in this country was opened by Sir William Bragg, president of the Royal Society, at the works of Pilkington Bros., St. Helens.

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The 22nd annual meeting of the Association of British Chemical Manufacturers was held in London under the chairmanship of Mr. E. V. Evans. Dr. F. H. Carr was elected president for the ensuing year.

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Capable of producing 50,000 tons per annum, Fison, Packard & Prentice, Ltd.'s new £70,000 factory at Ipswich was opened by Lord Cranworth, Chairman of the Land Fertility Committee.

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Sir Robert Ludwig Mond, distinguished by his contributions to chemical and physical science and elder son of the late Dr. Ludwig Mond, one of the founders of the Brunner Mond Co., died in Paris.

November

E.I. du Pont de Nemours announced that they had succeeded in producing a fibre from synthetic resins amenable to large-scale manufacture.

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The British Coal Utilisation Research Association decided to establish an experimental station at West Brompton, London, where premises were secured.

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Dr. George Stafford Whitby, Director of the Division of Chemistry, National Council, Canada, was appointed Director of the Chemical Research Laboratory, Teddington, in succession to Sir Gilbert Morgan.

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After nine months of negotiation the Anglo-American Trade Agreement, which relates not only to the United Kingdom, but also to Newfoundland and the Colonial Empire, was signed.

December

The annual Ramsay Chemical dinner was held at the Central Hotel, Glasgow, Mr. J. Davidson Pratt presiding. The toast of the "Profession of Chemistry" was proposed by Sir John Boyd Orr, director of the Rowett Research Institute and director of the Imperial Bureau of Animal Nutrition.

* * * *

The Land Fertility Committee reported that the total State contribution to the Land Fertility Scheme from its inauguration on September 6 last year to May 31 was £1,071,000. Altogether 207,000 applications were received from 140,000 farmers, who used 1,395,000 tons of lime and 409,000 tons of basic slag.

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Mr. Peter F. B. Bennett, a director of Imperial Chemical Industries, Ltd., and president of the F.B.I., Mr. F.D'Arcy Cooper, Chairman of Lever Brothers and Unilever, Ltd., Sir George Beharrell, Chairman of the Dunlop Rubber Co. and past president of the F.B.I., Mr. J. S. Addison, managing director of Courtaulds, Ltd., and a director of Samuel Courtauld & Co., Ltd., and Lieut.-Col. J. H. M. Greenly, President of the Institute of Fuel, were among those selected by the Government to serve on an industrial advisory panel on re-armament.

Chemical Trade During 1938

The Trend in Market Quotations for Industrial Chemicals

TRADE in industrial chemicals during 1938 followed a quietly steady course with moderately active conditions prevailing for the greater part of the period. At the commencement of the year some expansion in the volume of trade appeared likely but such hopes did not materialise, indeed, taking the year as a whole, the volume of business actually put through was in the aggregate probably just a little below that of the previous year and, as in 1937 so in 1938, there was room for considerable improvement.

Business in an Atmosphere of Hesitancy

To what extent the demand was influenced by events abroad and the prolonged uncertainty in the European political situation it is hard to say. Undoubtedly business in nearly all sections of the market was conducted in an atmosphere of hesitancy. Many of the consuming industries found it necessary to follow a cautious policy in production and this accounted largely for the slow movement in ex-contract deliveries. For the same reason quite the bulk of new business was transacted on a spot or near delivery basis and for quantities that were no more than sufficient to meet existing requirements.

The low stocks of chemical raw materials held by consumers made the need for supplies more acute during the September crisis when dealers were not in a position to execute a large volume of firm spot orders When the strain was relaxed buyers were in possession of useful stocks or had entered into commitments to cover requirements for some time ahead and it was not surprising that the subsequent months should witness a lull in normal trading activity.

The decline in the volume of trade during the latter months of the year cannot be taken as a fair indication of the normal trend of the market because proper allowance must be made for the difficult conditions with which dealers and buyers had to contend. In some quarters the outlook has not changed very much and extreme caution still prevails. In other directions a more hopeful view is taken, perhaps due to the further expansion in the re-armament programme which indirectly at least will benefit many sections of the chemical market.

It has already been announced that existing contract rates are to continue for 1939 delivery for such products as ACETIC ACID, FORMIC ACID, BORIC ACID, TRISODIUM PHOSPHATE, SODIUM DICHROMATE and POTASSIUM DICHROMATE, but there remain quite a large number of items for which contract rates have yet to be announced. The volume of forward buying, although of satisfactory dimensions, is not greater than for the same period a year ago. Generally speaking values for chemical products during 1938 remained fairly stable and, with few exceptions, prices moved within narrow limits. There were a number of price changes and the tendency, if anything, was inclined to lower levels.

Items Quoted at Higher Figures

It is of interest to note the trend in market quotations for industrial chemicals during the past twelve months. Higher quotations are ruling for items such as GLAUBER'S SALTS (commercial quality) which is now quoted from £3 5s. to £4 per ton in single bags according to quantity and shows an advance of about 20s. per ton. SODIUM BISULPHITE at £14 10s. per ton for bulk quantities is also substantially higher. SODIUM SULPHITE (commercial) is now quoted at £10 per ton and SODIUM HYPOSULPHITE, both commercial and photographic quality, is a little firmer at £11 10s. and £14 5s. per ton respectively. CAUSTIC SODA advanced by approximately 20s per ton and COPPER SULPHATE at £19 10s. per ton is 25s. per ton higher than at the beginning of 1938. BLEACHING POWDER advanced from £8 12s. 6d. to £9 15s. per ton, and quotations for IODINE and POTASSIUM IODIDE also advanced during the year, the makers' scale of prices for the latter item now ranging from 5s. 3d. to 7s. 3d. per lb. according to quantity. CHROMIUM OXIDE at 11½d. per lb. and LAMP BLACK at £24 to £26 per ton are both a little dearer on the year.

Products which now have a lower market quotation compared with the same period twelve months ago include AMMONIUM CHLORIDE, AMMONIUM SULPHATE, CALCIUM ACETATE, LEAD ACETATE, LEAD NITRATE, and SODIUM ACETATE. A substantial decline in GLYCERINE can also be recorded and c.i.f. quotations for ANTIMONY OXIDE fell from £50 per ton to £37 10s. The home makers reduced the price of CITRIC ACID by ¼d., the quotation now being 1s. per lb. less 5 per cent. CASEIN declined rather heavily with the current price of £19 per ton, c.i.f. London, as against £37 per ton. CALCINED MAGNESITE is now quoted at £8 to £9 per ton in bags ex works, and MAGNESIUM CHLORIDE at £5 10s. per ton, ex wharf, both these items being 20s. per ton cheaper than a year ago. MERCURIC OXIDE, red, B.P.C. crystals at 6s. 6d. per lb. for cwt. lots, SODIUM CYANIDE at 7d. per lb. for ton lots and SODIUM PERBORATE at 9d. per lb., delivered, are all slightly lower in quotation than for the corresponding period twelve months ago. ZINC CHLORIDE 102° Tw. at £10 per ton compares with the price of £13 per ton of a year ago. CADMIUM SULPHIDE quotations fell from 7s. 6d. per lb. to 3s. 9d. per lb. and CARBON BLACK at 3⅜d. to 4 1/16d. is also a little easier.

Items Showing Little Change

Most of the wood distillation products enjoyed a fair turnover on the year with values perhaps a shade lower than those ruling a year ago. There were few changes of any importance in other directions. Most of the potash and soda products followed a very steady course and few changes, if any, are expected in the rates for new contract bookings. ACETIC ACID was steady throughout the year, the 40 per cent. technical quoted at £16 12s. 6d. and the 80 per cent. technical at £30 5s. per ton. FORMIC ACID continues steady at about £42 per ton for ton lots, ex store, but smaller parcels obtained as much as 47s. 6d. per cwt. OXALIC ACID was a quiet market for the greater part of the year with the demand showing some improvement during the latter months; quotations for bulk quantities remain steady at £48 5s. per ton up to 57s. per cwt. for smaller quantities. PARALDEHYDE technical at £52 10s. per ton, delivered, and FORMALDEHYDE 40 per cent. at £20 to £22 per ton, in casks, ex store, both remained unchanged during the year with the last-named item showing a distinctly firmer tendency. With values for the metal remaining fairly steady throughout the year there were scarcely any fluctuations in the convention quotations for LEAD OXIDES and WHITE LEAD, prices for the former ranging from £29 10s. to £32 per ton according to quantity, less 2½ per cent., and for WHITE LEAD £36 10s. to £42 per ton, according to quantity, less 5 per cent. These quotations are on carriage paid terms. A steady demand was put through for TARTARIC ACID, the United Kingdom manufacturers' quotations remaining unchanged throughout the year at 1s. 1¼d. per lb., less 5 per cent. discount with competitive rates ruling for imported material. CREAM OF TARTAR was another item that enjoyed a steady market at unchanged values. SALAMMONIAC was quite a firm market, the dog-tooth crystals being quoted at £37 and the fine white crystals at £18 per ton, and LITHOPONE was in steady demand with quotations for red seal ranging from £16 10s. to £17 15s. per ton, ex store, according to quantity. ARSENIC values have remained very steady in spite of an exceedingly slow market, quotations for Cornish white Arsenic being £12 5s. to £12 10s. per ton, according to quantity and imported white powdered about £10 10s. per ton, c.i.f., U.K.

Trade in coal tar products was far from brisk during 1938. For the greater part of the year dull conditions prevailed and

quotations steadily declined. CARBOLIC ACID CRYSTALS are quoted at about 8d. per lb., which is about 1d. per lb. cheaper than at the commencement of the year. Crude 60's, however, have declined from 4s. 3d. per gallon to 1s. 9d. per gallon, and the dehydrated from 4s. 9d. per gallon to a nominal price of 2s. 6d. per gallon. CREOSOTE at 4d. per gallon f.o.r. makers' works, for home trade, compares with 6¾d. per gallon at the beginning of the year. CRESYLIC ACID also shows a substantial drop in quotations; 99/100 per cent. 3s., pale 99/100 per cent. 2s. 2d., dark 95 per cent. 1s. 7½d. and an American specification 3s. 10½d. per gallon compares with 5s. 6d., 4s. 7d., 3s. 11d. and 4s. 6d. per gallon respectively, which prices ruled twelve months ago. NAPHTHALENE is now quoted at about £5 per ton and shows a fall of £3 on the year. SOLVENT NAPHTHA is cheaper and PITCH has fallen from 37s. to 31s. per ton. TOLUOL and XYLOL are both about 1d. per gallon cheaper than at this time last year.

In view of the inactive conditions now prevailing market quotations for the majority of the coal tar products are regarded as nominal only. Much of the slackness in this market has been due to the large stocks accumulated by consumers, but such stocks must now be considerably reduced and with the demand returning to normal dimensions some recovery in the price position can be expected.

North-Eastern Trading Estates Limited

Review of Operations During 1938

THE Directors of North-Eastern Trading Estates Ltd. can look back with satisfaction upon the progress made by this Government sponsored enterprise during the year 1938. At January 1, 1938, the tenants numbered 76, of whom 29 were then occupying their factories and employing 800 people. Twelve months later 43 more firms had been added to the list of tenants of properties administered by the estate company; 85 had occupied their buildings and were employing 2,200 people. Most of these had only been in occupation for a few months and had scarcely had time to set the wheels of trade in motion, but it is significant that factory employment has recently been increasing at the rate of approximately 200 a month, and in 1939 the capacity of the factories let should amount to 5,000 or 6,000 people. Inquiries for factory sites show no signs of abating and it is evident that Team Valley Trading Estate has now passed well beyond the experimental stages.

Great progress has been made with the engineering development of the estate which now possesses a complete network of wide roads. A full gauge internal railway, six miles long, has been completed, and links every factory requiring rail access direct to private sidings on the L.N.E.R. main line which forms the east boundary of the estate.

Well equipped canteens have been erected for employees, the first of which was opened by the Marchioness of Londonderry on July 12. On August 1 the estate company occupied their fine central administration building, and not long after that date offices in it were taken by professional and public organisations, all of which in various ways serve the interests of the estate and its industrial tenants.

In the forthcoming year it is hoped to arrange a series of visits to Team Valley for manufacturers from other parts of England.

A smaller industrial site of 22 acres at St. Helens Auckland in South West Durham was opened by Sir George Gillett, Commissioner for the Special Areas, on October 14. This site is being developed and managed by North Eastern Trading Estates, Ltd. A fourth tenant has recently been secured for this site. At Pallion, Sunderland, on another industrial site similarly managed by the estate company, two factories are now occupied, a third almost completed and a fourth scheduled. A further factory at Tynemouth was erected during the course of the year.

A NEW PHARMACEUTICAL PRODUCT

A new pharmaceutical product known as viridosan or lecichlorophyll has been put on to the French market. A combination of lecithin and chlorophyll, the new product serves mainly as a regulator of arterial tension. In order to render it more suitable for certain types of illnesses, the product is also prepared in combination with other substances, especially in the form of iodovirosan (with iodine) and digivirosan (with digitaline), ferrovirosan (with iron) and theovirosan (with a combination of theobromine and theophylline).

International Society of Leather Trades' Chemists

Progress of the British Section in 1938

THE two usual half-yearly meetings of the British Section of the International Society of Leather Trades' Chemists were held in March at Leeds, and in October at London during the period of the Shoe and Leather Fair. At both meetings excellent papers were given on the action of light on animal fibres, with special reference to the dyeing of sheepskins and furs, by Dr. J. B. Speakman; on a simple method for the determination of the birefringence of animal fibres, by Dr. R. H. Marriott; on the examination of different types of leather by means of X-rays, by Dr. Dorothy Jordan Lloyd; and on water solubles in leather and "mustiness" in leather, by Dr. A. Colin-Russ. In addition, a very successful combined meeting with the London Section of the Oil and Colour Chemists' Association took place on November 18 last when the subject of pigment finishes was discussed (see THE CHEMICAL AGE, November 26, 1938, 411).

The parent Society has selected London as the venue of the next biennial conference in 1939, at which the British Section will be the hosts. The conference will be held at the Polytechnic, Regent Street, London, W.1, from August 28 to September 1 inclusive, and a large number of continental leather chemists are expected.

During the year the Society published its official methods of analysis in book form (price 5s. to members and 8s. 6d. to non-members). In addition to giving details for examining tanning materials and leather, methods have been standardised for examining other materials used in the production of leather.

The recently elected officers of the British Section for 1939 are: President, R. Faraday Innes, F.I.C.; vice-president, R. O. Phillips, M.Sc.; hon. treasurer, Dr. D. Burton; committee, Dr. R. H. Marriott and Messrs. J. Hill and G. Forsyth; hon. secretary, A. Harvey.

DRUG CONTROL IN INDIA

The urgent need for proper drug standardisation and for a comprehensive scheme of drug control has been brought out by a recent investigation undertaken by the Biochemical Standardisation Laboratory, Calcutta (set up by the Government of India), into the liquid preparations of ergot, sold in the Indian market and in common use for medicinal purposes. Of 130 samples of ergot preparations tested in the Laboratory, 112 or 86.15 per cent. were found much below strength and in 58 or 44.61 per cent. no active principles whatever could be detected. Of the samples examined, 103 were of indigenous manufacture and 27 of foreign make. While the deterioration of the active principles of ergot in the hot and humid climate of India may be an important factor in bringing about the poor quality of these preparations, the opinion is expressed that it seems probable also that an inferior quality of both crude and finished preparations of ergot, unsaleable in their countries of origin due to stringent drug laws, are being purchased in India at a cheap price.

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Chemical Manufacture in Canada

Industrial Gases and Hardwood and Coal Tar Distillates

REPORTS on three individual industries in the chemical group of Canadian manufactures have now been issued for last year. The industries are those engaged in the making of industrial gases, hardwood distillates and coal tar distillates. The hardwood distillation industry was the only member of the chemical group to show a decline for 1937, and this decline was small. The compressed gases industry showed a gain of 17 per cent. and coal tar distillation a gain of 15 per cent. The output value of the chemical group as a whole was the highest on record and exhibited an increase of 14 per cent. over 1936.

The value of production in the compressed gases industry of Canada last year, according to a report recently published by the Dominion Bureau of Statistics, was $3,929,200. This was the highest value reported for this industry since 1929. The plants reporting in the industry last year numbered 27 and the capital investment was $4,605,100. The output of oxygen increased 28 per cent., acetylene 17 per cent., and carbon dioxide (in cylinders) 18 per cent. The output of hydrogen declined slightly. The value of the output in the hardwood distillation industry last year was $749,000. This compared with $857,600 in 1936. Five plants were engaged in the operations of this industry last year and the capital employed was $1,546,300.

The gross selling value (at the works) of the products of the coal tar distillation industry in 1937 was $3,399,500. This was the highest value recorded since 1929. Ten establishments reported in the industry last year and the capital was valued at $4,392,400.

The total value of output in the chemical group of Canadian manufactures last year was $144,993,000 as compared with $126,874,000 in 1936. The previous record for the group was set up in 1929 at $138,545,000. The largest values reported by individual industries last year were medicinals and pharmaceuticals $24,232,000, paints, pigments and varnishes $24,152,000 and acids, alkalies and salts or heavy chemicals $22,340,000.

Indian Heavy Chemicals Manufacture

New Enterprise by the Tata Concern

TATA SONS, LTD., have started a new venture in the Indian chemical industry by the manufacture of heavy chemicals in the Baroda State for which the State will give special facilities. The authorised capital of the enterprise is Rs. 5 crores of which Rs. 1¼ crores will be issued at present.

The company will set up its works near Port Okha which belongs to the Baroda Government, which, besides granting valuable concessions, will subscribe shares to the extent of one-fifth of the present issue. Although the initial programme of the company is confined to the manufacture of basic heavy chemicals, such as soda ash and caustic soda, the company contemplates the gradual development of the undertaking so as to embrace practically the whole field of production of heavy chemicals and fertilisers as well as special chemicals for use in industries such as pharmaceutical and photographic.

The scheme is being undertaken after two years of patient and careful preparation and a thorough examination at the hands of British, American and other experts, who have satisfied the promoters as to the possibility of working it successfully.

PLANS have been announced for the development of phosphate deposits in the vicinity of La Caunette (Department of Hérault, France) consisting mainly of calcium and aluminium phosphates.

Letters to the Editor

The Five Day Week

SIR,—We welcome the opportunity you have given us of sending the greetings of all at the Andrew's Liver Salt factory to another firm that operates a five day week.

We have now worked a five day week for just over 3½ years, and from the point of view both of the management and the staff, we are entirely satisfied with the result.

We realise, of course, that there are some trades where this most desirable shortening of the working week would be much more difficult to introduce, but we join with you in hoping that two free days per week may soon be the rule, rather than the exception, and that those benefiting by the extra free time will find still greater opportunities of enjoying it fully and beneficially.—Yours faithfully,

SCOTT AND TURNER, LTD.

Newcastle-upon-Tyne, 2.
December 28.

SIR,—We have never regretted going on to a five day week in our factory. When we first contemplated taking this step fears were expressed that our production would suffer and that we should find that our labour costs would increase. We are glad to be able to record that in regard to our output our tonnage has increased, while our labour costs have decreased, proving in this way that the move has been really a good one for us.

Naturally we have not stood still, and we have introduced new types of machinery, but even taking this factor into account we are satisfied that in the increased efficiency of our workers through the long week-end we have gained very materially.—Yours faithfully,

CARR AND CO., LTD.
E. P. Brown,
Managing Director.

Carlisle.
December 28.

Neutral Bath Wool Dyeing

Harmful Effects Arising from Incorrect pH

THE alleged harmful action of dyeing wool in a neutral bath has been studied by Speakman and Cole (*Jour. Soc. Dyers and Colourists*, 1938, *54*, 563-565. "Neutral dyeing," that is the practice of dyeing in the presence of sodium sulphate alone, without any addition of acid—when using colloidal dyes that are inclined to produce unlevel effects when used in acid solution, since they become too colloidal, is regarded by many practical dyers as having a very harmful effect on the dyed wool.

To investigate the truth of this statement fibres were immersed in sodium sulphate solution. The effect of the solution on unstrained fibres at the boiling point, and on strained ones at various temperatures, was practically nil, so that the cause of the supposed action must be sought in some other feature of the neutral dyeing process. This has been located in the fact that before dyeing, wool is usually scoured in soap. This results in it taking up a considerable amount of adsorbed alkali, which raises the *p*H of the dyebath well above the neutral point. It was found that the *p*H at which least deterioration of the wool took place was 5.5; both higher and lower *p*H's are more harmful, but particularly higher ones. A *p*H of 7 has a more deleterious action than one of 2, and the damage at *p*H 8 was three times that at *p*H 5.5. The remedy appears to lie either in using a neutral scouring agent or in buffering the dyebath at the optimum *p*H by the use of ammonium acetate. The reason why the chromate process results in satisfactory dyeing with very little damage to the wool is probably because it operates at a *p*H of 6.

CHEMICAL ENGINEERING IN 1938

(*Continued from page* 518.)

steatite lava and porcelain mixtures at high rates of production. The Berl Saddle, one of the latest forms of tower packings is produced at the rate of 350 pieces per minute by dry compressing on fully automatic machines.

In the electrical industry one finds produced by dry compressing a wide variety of insulators and resistances, carbon resistance discs, motor car starter motor brushes with wires inserted, adjustable iron cores, tungsten contact points; and, from ceramic compounds, mercury containers for noiseless switches, socket bases, fish tail beads, spacer discs for radio tubes, terminal blocks; and, from powdered glass, glass insulating beads.

Even powdered metals are compressed into such products as self-lubricating or oil-less bearings, generator or starter brushes round copper coils, ore charge briquettes, small valve seats and radio parts, and metallic iron round brass screws. In the preforming of plastics and the debulking or densifying of moulding powders, dry compressing has made big strides. The use of catalysts in tablet form has had extensive application in the chemical field.

Distillation

The use of azeotropic distillation in industry for the object of achieving continuous instead of batch operation was the subject of a paper before the Institution of Chemical Engineers by Guinot and Clark. The production of absolute alcohol, ethers, certain esters and aliphatic acids are now primarily dependent on this method of operation.

Drying

The preforming of certain materials into so-called "aeroform shape" because of their difficulty in drying was reported on by Hurxlhal (*Ind. Eng. Chem.*, 1938, *30*, 1,004-1,006). The material is formed into strips sufficiently rigid to break into short lengths and then dried on a continuous conveyor. The advantage is due to the exposure of more surface to the heated air stream and to the ease of handling. The high cost of such plant has resulted in the use of a machine known as an oscillating granulator in another industry. The drying and handling of filter cake and other damp masses is greatly speeded up when the materials are first broken down by the machine to granules which expose more drying surface. The machine further acts as a distributor to the conveyor, when such is used in the drying system. This development is typical of the fundamental character of chemical engineering, because it is an example of a machine developed for one purpose being found of value in another industry.

Sterile Technique

The adoption and standardisation of a new form of sterile technique in the production of injections has been the subject of a series of patents, and a factory to produce such products by these methods will shortly be in operation. It is possible that far-reaching developments in this field will be achieved in the near future.

Education

The recent enactments of the University of London in support of the conception of chemical engineering as a separate and distinct branch of applied science, has strengthened that view, and the development of suitable curricula for the training of the chemical engineer on a broad basis, with the avoidance of specialisation, is now a logical sequence.

THE successful operation of the experimental plant for iron manufacture from bauxite at Pét, Hungary, where the daily throughput of bauxite has so far amounted to 5 tons, has led to a decision to extend the plant.

Recent Trade Literature

Steel ground manhole covers which cannot be broken by lorries or by rough treatment are a product of ROBERT JENKINS AND CO., LTD., who have recently issued a revised and enlarged list to the trade.

The growing realisation that eventually there will be some form of national direction of the location of industry or at least some discouragement of expansion in the London area, is already leading many industrialists, who are preparing plans for extension, to look more closely than they otherwise might have done into the possibility of other parts of the country. In this connection HULL CORPORATION, through their development committee, have issued a brochure explaining the advantages of establishing industrial undertakings in the city.

SIEBE, GORMAN AND CO., LTD., manufacturers of the Mark IV Dust Respirator have issued a leaflet describing this latest addition to their range. Designed at the suggestion of the Department of Scientific and Industrial Research and manufactured under Home Office Licence, this respirator is claimed to afford complete protection against the minute ultra-microscopic particles which cause silicosis, asbestosis and kindred complaints such as are met with in grinding and other industrial processes. It comprises a face-piece of flexible moulded rubber having secured to it on either side a filter unit of asbestos-wool mixture covered with black fabric and quilted. The total filtering area is approximately 54 sq. inches.

IMPERIAL CHEMICAL INDUSTRIES, LTD., have recently issued an auxiliary products pamphlet which describes Dispersol RT, a new product used for the production of level shades on wool which has been damaged by uneven exposure, either during growth on the sheep's back or when scoured wool pieces and yarn have been stored in a damp condition. Dispersol RT has also been found useful for level dyeing on garments which have been unevenly exposed in wear. The cause of such unevenness and methods of obtaining level results (with a selection of dyestuffs which give level results when applied by normal dyeing methods) are described in the pamphlet.

Drayton circular chart recorders, manufactured by the DRAYTON REGULATOR AND INSTRUMENT CO., LTD., are described in a leaflet issued by the company. The construction of these temperature and pressure instruments is described as robust, and ample margin is provided to enable the instrument to withstand normal usage. All parts which are of necessity of a fragile nature are protected against accidental damage to the fullest possible extent. Every convenience to facilitate chart changing, winding, etc., is provided and all instruments are fitted with zero adjustment to the pen arm, which permits a "dead-on" reading to be obtained at any one point in the calibrated range. The company maintains that the cost of recording instruments is trifling and the upkeep negligible, the value of the information they subscribe varying between ease of mind and a major displacement in the profit and loss account.

DOULTON AND CO., LTD., have produced a journal entitled "Ceramics in Art and Industry," which they propose issuing from time to time to enable customers and friends to obtain a better insight into the vast field covered by modern ceramic production. Special sections are devoted to stoneware pipes, chemical ware, electrical porcelain and laboratory porcelain. The chemical engineer's greatest problem is probably that of corrosion. Stoneware resists the attacks of all acids, except hydrofluoric, in all concentrations; and though in recent years the metallurgist and the chemist have also taken up the fight against corrosion, qualifications of various kinds govern the use of almost all materials, other than stoneware, and where they do not, the cost of production prohibits their use on an industrial scale. Apart from the great resistance of stoneware to acid corrosion, the material has also the advantage of a flexibility in design which is possible only in a material made of plastic clays.

Personal Notes

DR. E. H. F. BALDWIN, St. John's College, has been re-appointed demonstrator in bio-chemistry at Cambridge University for five years from January 1, 1939.

MR. UDOLPHUS AYLMER COATES, formerly head chemist and analyst to R. Parkinson and Sons, manufacturing chemists, Burnley, and MRS. COATES, celebrated the diamond jubilee of their wedding on Christmas Day. Mr. Coates served in the capacity of head chemist and analyst to Parkinson and Sons from 1890 until his retirement in May, 1928. He is a member of the Society of Public Analysts, and is hon. auditor and a founder of the North of England section branch. He is also a member of the Pharmaceutical Society of Great Britain, and in 1923 he was appointed first president of the Burnley branch of the Society.

OBITUARY

MR. HAROLD GUNDRY, a director of the South Metropolitan Gas Co. and the South Suburban Gas Co., died at Hampstead at the age of 78.

TO-DAY'S ANNIVERSARY

JOHN STENHOUSE, professor of chemistry in the medical school at Guy's Hospital, London, died on December 31, 1880, at the age of 71. His many investigations included a study of the colouring matter of some of the lichens, in particular orchil, which he obtained by macerating various species of lichens with dilute ammonia and caustic soda, allowing the extract to ferment and then recovering the actual colouring matter by the addition of sulphuric acid and salt. At the present day orchil finds a use in the dyeing of carpet yarn, and to a certain extent for modifying the effect of other dyes, especially those of vegetable origin. Kekulé, while engaged as an assistant to Stenhouse, thought out his theory of "molecular architecture" (as he called it) or structure of the organic molecules.

Foreign Chemical Notes

Germany

PETROLEUM PRODUCTION at 451,000 tons was 6,400 tons higher in 1937 than in the previous year. This compares with crude petroleum imports of 732,000 tons.

Latvia

A COMMISSION HAS BEEN SET UP by the Ministry of Agriculture to investigate the possibility of extracting fats from animal waste and corpses with a view to reducing imports of technical oils and fats.

France

THE DAILY OUTPUT CAPACITY OF THE NEW NITRIC ACID PLANT of the Soc. de Produits Chimiques Engrais d'Auby at Feuchy is 85 tons of 36° acid although it is at present only turning out about 70 tons.

Hungary

AN ASPHALT FACTORY IS TO BE BUILT in Budapest by the Palatinius Building Company.

THE HUNGARIAN MUNITIONS WORKS CO. has been formed in Budapest with a capital of 500,000 pengo and will engage among other objects in the processing of petroleum and other oils.

Sweden

MANUFACTURE OF FILTER MEDIA FOR GASPROOF ROOMS and other air raid protection materials is contemplated by the Malmoö firm of A. B. Wilhelm Sonesson and Co.

PERMISSION FOR THE ERECTION OF A SULPHITE SPIRIT FACTORY with an annual capacity of 40,000 hectolitres has been granted to Mooch Domsjö A.B.

From Week to Week

THE NEWLY-BUILT FACTORY OF THE BRITISH ALUMINIUM CO., at Newport (Mon.), has received 2,480 tons of bauxite ore, its first cargo, from Toulon.

FIRE BROKE OUT on December 17 in the pressroom of the I.C.I. explosives factory at Linlithgow, one employee being fatally injured. The fire was confined to one room.

THE 76TH ANNUAL MEETING OF THE INSTITUTION OF GAS ENGINEERS will be held in London from June 6 to June 9, 1939, and the eleventh autumn research meeting will be in London on November 7 and 8, 1939.

THE SOUTH AFRICAN PAVILION AT THE EMPIRE EXHIBITION, Glasgow, has been purchased as a recreation hall for their workers, by Nobel Explosives, Ltd., Ardeer. The pavilion is to be taken down shortly and re-erected in its present form at Ardeer.

LORD DERBY WILL BE THE PRINCIPAL GUEST at a luncheon to members of the home, Empire and foreign Press on February 20, the opening day of the British Industries Fair. The Earl of Dudley will preside at the luncheon held during the preliminary view of the Birmingham section of the Fair on February 17.

NEGOTIATIONS FOR THE SALE of the Aussig Chemical Works, formerly Czecho-Slovakia's greatest chemical enterprise, have come to a successful end, it is reported. The works at Aussig and Falkenau, both in the Sudetenland, will be taken over by a German concern, the main interest in which is held by the German Dye Trust.

VOLUME 14 OF THE JOURNAL OF THE ELECTRODEPOSITORS' TECHNICAL SOCIETY has recently been issued. Produced annually the Journal contains the proceedings of the Society including the reproduction of papers which have been presented either in London or Birmingham during the session 1937-38. The price of the volume to members is 15s., and to non-members one guinea.

COMMERCIAL SOLVENTS CORPORATION have announced that their London Office at Aldwych House, Aldwych, W.C.2, will be closed on and after December 31, 1938, and that all communications which in the past would have been addressed to the London Office of the Corporation should in future be addressed to the Corporation's head office at 230 Park Avenue, New York City, U.S.A.

AS FROM JANUARY 1, 1939, the London offices of Croda, Ltd., Goole, Yorks, will be moved from Willesden to 403-404 Cecil Chambers, Strand, London, W.C.2, telephone number: Temple Bar 1833; telegraphic address: Croda, Phone, London. The firm's rapidly increasing business in the South of England, has necessitated their moving to more commodious and more central premises in London, where in future the technical director (Mr. E. Cannon), will be in charge to advise purchasers of data which they may need.

MR. LLOYD ROBERTS ON BEHALF OF IMPERIAL CHEMICAL INDUSTRIES, LTD., told representatives of the various engineering unions recently that their claim for an increase of 10s. a week in wages had not, in the company's view, been established; that the existing level of earnings was satisfactory in relation to the wages paid for similar work elsewhere; and that the prevailing political and economic international uncertainties made it imprudent to embark at the present time on any measure that would enhance costs of production.

THE TREASURY, ON THE RECOMMENDATION OF THE IMPORT DUTIES ADVISORY COMMITTEE, has made an order which provides for the addition to the free list of alloys containing less than 95 per cent., but not less than 90 per cent. of silicon. Silicon and alloys containing not less than 95 per cent. of silicon are already exempt, but the Advisory Committee stated that experience had shown that there were importations of alloys of silicon containing between 90 and 95 per cent. of silicon which could not be regarded as ferro-silicon and therefore eligible for free admission.

OUT OF THE FUND FOR RESEARCH obtained by the Land Fertility Committee from the lime and slag subsidy to the farmers and from the approved lime suppliers, £11,500 is to be spent in the current year on schemes to increase land fertility. Of this, £4,300 is to be allotted to cover cost of free analysis of soil samples as a guide to the fertilisers required. The remaining £7,200 is to be split equally over twelve existing advisory centres to provide further laboratory and field assistance in carrying out survey work on areas in which lime or phosphate is deficient in the soil.

THE HOME SECRETARY announced last week that he had made regulations under Section 1 of the Hydrogen Cyanide (Fumigation) Act, 1937, for the fumigation of buildings with hydrogen cyanide. The regulations, which are substantially in accordance with the draft issued on January 14, 1938, will come into force on February 1, 1939. Copies of the regulations which may be cited as The Hydrogen Cyanide (Fumigation of Buildings) Regulations, 1938, can be purchased directly from His Majesty's Stationery Office at York House, Kingsway, W.C.2, 120 George Street, Edinburgh 2, 26 York Street, Manchester 1, 1 St. Andrew's Crescent, Cardiff, or through any bookseller.

Inventions in the Chemical Industry

The following information is prepared from the Official Patents Journal. Printed copies of Specifications accepted may be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2, at 1s. each. The numbers given under "Applications for Patents" are for reference in all correspondence up to the acceptance of the Complete Specification.

Applications for Patents

PRODUCTION OF RESINOUS CONDENSATION PRODUCTS.—Beck, Koller and Co. (England), Ltd. (Hovey and Hodgins). 36353.

COLOURING MATTERS of the phthalocyanine series.—E. F. Bradbrook, S. Coffey, N. H. Haddock, and Imperial Chemical Industries, Ltd. 35892.

PRODUCTION OF CELLULOSE DERIVATIVES.—British Celanese, Ltd. (United States, Dec. 10, '37.) 36056.

MANUFACTURE OF COMPOUNDS OF THE DIARYL SERIES.—A. Carpmael (I. G. Farbenindustrie.) 35881.

MANUFACTURE OF LEUCO SULPHURIC ACID ESTERS of vat dyestuffs of the anthanthrone series.—A. Carpmael (I. G. Farbenindustrie.) 36480.

PRODUCTION OF STARCH PRODUCTS.—Corn Products Refining Co. (United States, Dec. 10, '37.) 36082, 36083.

MANUFACTURE OF OLEFINE OXIDES.—Distillers Co., Ltd., and H. Langwell. 36112.

ADHESION OF RUBBER TO TEXTILE MATERIALS.—Dunlop Rubber Co., Ltd., D. F. Twiss, R. M. Everett, and F. A. Jones. 35925.

PRODUCTION OF POLYMERISABLE ESTERS, ETC.—E. I. du Pont de Nemours and Co., and H. S. Rothrock. 36355.

ARYLENETHIAZOLE DERIVATIVES.—F. S. Fowkes, and Imperial Chemical Industries, Ltd. 36003.

METHOD OF HYDROGENATING KETONES, ETC.—J. Frasch. (France, Dec. 17, '37.) 35947.

PRODUCTION OF ACTIVE CHARCOAL.—Gas Light and Coke Co., R. S. Chaplin, and N. E. Siderfin 36091.

MANUFACTURE OF INTERPOLYMERISATION PRODUCTS.—W. W. Groves (I. G. Farbenindustrie.) (April 2, '37.) 36301.

MANUFACTURE OF UNSATURATED NITRILES.—H. Gudgeon, and Imperial Chemical Industries, Ltd. 36004.

MANUFACTURE OF UNSATURATED ESTERS.—H. Gudgeon, R. Hill, and Imperial Chemical Industries, Ltd. 36477.

MANUFACTURE OF HIGH BLEACHING POWDER stabilised products. J. Halden and Co., Ltd., and J. Holden. 35939.

EXTRACTION OF ZINC, ETC., from their ores.—F. W. Harbord, V. Harbord, and E. F. Law. 36060.

MANUFACTURE OF ACID WOOL DYESTUFFS.—I. G. Farbenindustrie. (Germany, Dec. 8, '37.) 35878.

MANUFACTURE OF ZIRCONIUM METAL.—I. G. Farbenindustrie. (Germany, Dec. 9, '37.) 35879.

MANUFACTURE, ETC., OF MONOCHLORHYDRIN MONO-NITRATE.—I. G. Farbenindustrie. (Germany, Dec. 15, '37.) 35989.

MANUFACTURE OF CONDENSATION PRODUCTS.—I. G. Farbenindustrie. (Germany, Dec. 10, '37.) 36108.

ENHANCING THE FASTNESS TO WATER OF DYEING ON TEXTILES.—I. G. Farbenindustrie. (Germany, Dec. 24, '37.) 36438.

CONCENTRATION OF RUBBER LATEX.—L. Mellersh-Jackson. (United States Rubber Co.). 35867.

PREPARATION OF PHYTOLIPASES.—A. Karreth. 36489.

MANUFACTURE OF HYDROCARBON GASES.—T. D. Kelly. 36159.

MANUFACTURE OF BARIUM CARBONATE.—B. Laporte, Ltd., I. E. Weber, and W. S. Wood. 36435.

PROCESS FOR PREPARING ARSENATES by anodic oxidation of salts by arsenious acid.—L. Lowenstein. (Germany, Dec. 13, '37.) 35873.

PREVENTION OF THE CORROSION OF MAGNESIUM, ETC., ALLOYS.—Magnesium Elektron, Ltd. (Germany, Jan. 15.) 36233.

CHEMICAL MANUFACTURE.—Mathieson Alkali Works. (United States, Dec. 18, '37.) 35851.

ALKALOIDS OF SPECIES OF ERYTHRINA, ETC.—Merck and Co., Inc. (United States, Dec. 16, '37.) 35936; (United States, July 27.) 35937.

PREPARATION OF 2-METHYL-5-CHLOR-METHYL-6-AMINO PYRMIDINE HYDROCHLORIDE.—Merck and Co., Inc. (United States, Dec. 14, '37.) 36305.

PROCESS FOR REMOVING ACID COMPONENTS from hydrocarbons, etc. Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij. (United States, July 15.) 35865.

MANUFACTURE OF DERIVATIVES OF SULPHONAMIDES.—Schering, A.-G. (Germany, Feb. 2.) 35882.

MANUFACTURE OF DEGRADATION PRODUCTS containing carboxyl groups.—Schering, A.-G. (Germany, Dec. 18, '37.) 36481.

PROCESS OF TREATING MINERAL OILS with solvents.—Standard Oil Development Co. (United States, April 6.) 36154.

MANUFACTURE OF THERMO-SETTING SYNTHETIC RESINS.—Trey Frères Soc. Anon. (Switzerland, Aug. 23.) 36099.

TREATMENT OF HYDROCARBONS under the action of heat.—Trinidad Leaseholds, Ltd., and E. Heni. 35944.

MANUFACTURE OF ALIPHATIC KETONEDIARYL-AMINE ANTI-OXIDANTS. United States Rubber Products, Inc. (United States, Dec. 9, '37.) 35784, 35785, 35786.

PROCESS FOR THE EXTRACTION OF ORGANIC COMPOUNDS from mineral oil acid refining waste.—J. Winkler, W. J. Piotrowski, B. Spanier, K. Bauer, and Galicyjskie Towarzystwo Naftowe Galicja Spolka Akcyjna. (Poland, Jan. 3.) 35869.

PROCESS FOR THE PREPARATION OF HALOGENATED AMINES.—Wessamen's Koninklijke Fabrieken N.V. (Holland, Dec. 28, '37.) 36085; (Holland, Aug. 1.) 36086; (Holland, Sept. 13.) 36087, 36088.

Specifications Accepted with Date of Application

MANUFACTURE AND PRODUCTION OF VALUABLE HYDROCARBONS and their derivatives containing oxygen from carbon monoxide and hydrogen.—G. W. Johnson (I. G. Farbenindustrie.) June 3, 1937. 496,880.

PRODUCTION OF ACTIVE CARBON.—Brimsdown Chemical Works, Ltd., J. C. Liddle, and H. Meyer. June 3, 1937. 496,942.

DYEING CELLULOSE AND CELLULOSE DERIVATIVES.—A. Carpmael (I. G. Farbenindustrie.) June 3, 1937. 496,944.

PROCESS FOR THE MANUFACTURE OF PREPARATIONS containing the circulatory hormone callicrein.—A. Carpmael (I. G. Farbenindustrie.) June 4, 1937. 496,946.

MANUFACTURE OF CELLULOSE.—H. Dreyfus. June 7, 1937. 496,887.

TREATMENT OF CHROMIUM ORES.—G. F. Alexander. June 25, 1936. 496,890.

MANUFACTURE AND PRODUCTION OF SYNTHETIC RESINS.—G. W. Johnson (I. G. Farbenindustrie.) June 7, 1937. 496,815.

MANUFACTURE OF ACRYLOXY CARBOXYLIC ACIDS and their esters.—E. I. du Pont de Nemours and Co. June 5, 1936. (Samples furnished.) 496,892.

SEPARATION OF WAX from wax-containing hydrocarbon mixtures. Edeleanu-Ges. June 8, 1936. 496,955.

REFINING OF HYDROCARBON OILS.—Edeleanu-Ges. June 8, 1936. 496,956.

CHROMIUM-MANGANESE-NICKEL STEEL.—Electro-Metallurgical Co. June 11, 1936. 497,010.

STEELS.—Electro-Metallurgical Co. June 24, 1936. 497,011.

CORROSION-RESISTANT STEELS.—Electro-Metallurgical Co. June 11, 1936. 497,012.

LOW- AND MEDIUM-TEMPERATURE CARBONISATION PROCESSES and apparatus.—F. Puening. June 9, 1937. 497,066.

ANTHRAQUINONE DYESTUFFS.—R. N. Heslop, W. W. Tatum, and Imperial Chemical Industries, Ltd. June 9, 1937. 497,016.

PROCESS FOR THE MANUFACTURE OF TANNING AGENTS.—A. Carpmael (I. G. Farbenindustrie.) June 10, 1937. 496,898.

MANUFACTURE OF STABILISED HYDROCARBON POLYMERS.—Standard Oil Development Co. July 25, 1936. 496,966.

MANUFACTURE OF DERIVATIVES OF CYCLOPENTANOPOLYHYDROPHENANTHRENE.—I. G. Farbenindustrie. June 11, 1936. 497,022.

MANUFACTURE OF AFTER-CHROMABLE ACID DYESTUFFS of the triphenylmethane series.—W. W. Groves (I. G. Farbenindustrie.) June 11, 1937. 497,030.

MANUFACTURE OF ARTIFICIAL SUBSTANCES containing nitrogen.—W. W. Groves (I. G. Farbenindustrie.) June 11, 1937. 497,031.

UREA DERIVATIVES.—H. A. Piggott, J. D. Rose, and Imperial Chemical Industries, Ltd. June 11, 1937. 497,042.

QUATERNARY AMMONIUM COMPOUNDS.—H. A. Piggott, J. D. Rose, and Imperial Chemical Industries, Ltd. June 11, 1937. 497,043.

PROCESS FOR THE MANUFACTURE OF DYESTUFFS of the phthalocyanine series.—A. Carpmael (I. G. Farbenindustrie.) June 12, 1937. 496,819.

SYNTHETIC RESIN COMPOSITION.—R. R. Howroyd. June 12, 1937. 497,047.

MANUFACTURE AND PRODUCTION OF DYESTUFFS of the phthalocyanine series.—G. W. Johnson (I. G. Farbenindustrie.) June 18, 1937. 496,970.

FLOTATION OF CULM.—American Cyanamid Co., and H. A. Grine. Aug. 26, 1936. 496,901.

PROCESS FOR THE MANUFACTURE OF ANHYDROUS BERYLLIUM FLUORIDE free from oxide.—Seri Holding Soc. Anon. April 17, 1937. 496,773.

APPARATUS FOR THE MANUFACTURE AND PRODUCTION OF ACETALDEHYDE.—G. W. Johnson (I. G. Farbenindustrie.) Nov. 30, 1937. 496,840.

REMOVING NAPHTHENIC ACIDS from mineral lubricating-oils or lubricating-oil fractions.—Naamlooze Vennootschap de Bataafsche Petroleum Maatschappij. Jan. 4, 1937. 496,779.

PRODUCTION OF CAOUTCHOUC ARTICLES.—Chemische Fabrik J. A. Benckiser Ges., and A. Volz. Dec. 24, 1936. 496,780.

PRODUCTION OF AMMONIUM NITRATE and mixtures containing the same and apparatus therefor.—Directie Van de Staatsmijnen in Limburg. Jan. 6, 1937. 496,847.

MANUFACTURE AND PRODUCTION OF CARBOXYLIC ACID NITRILES.—I. G. Farbenindustrie, Jan. 20, 1937. 496,781.

HYDROLYSIS OF CELLULOSIC BODIES by hydrogen halides.—E. Neu. Aug. 9, 1937. 496,862.

PROCESS FOR THE MANUFACTURE OF COMPOUNDS of the cyclopentano-polyhydrophenanthrene series.—W. P. Williams (Schering Kahlbaum, A.-G.). May 6, 1937. 496,799.

PROCESS FOR THE MANUFACTURE OF ETHERS of 2-methyl-2-hydroxy-3-chloro-tetrahydrofurane.—F. Hoffman-La Roche and Co., A.-G. July 20, 1937. 496,801.

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New Companies Registered

British Wheat Salts Company, Ltd. 346,940.—Private company. Capital £100 in 100 shares of £1 each. To carry on the business of chemical manufacturers, etc. Subscribers: James F. Lowther, "Roseneath," Albert Road, Malvern; Carlton C. Lowther.

Montecatini Spa Products, Ltd. 346,525.—Private company. Capital £100 in 2,000 shares of 1s. each. To carry on the business of wholesale and retail chemists, analytical, research and manufacturing chemists, etc. Subscribers: John H. N. Gorvin, 21 Highfields, Sutton Common Road, Sutton; Leonard P. Law. Registered office: 55-56 Chancery Lane, W.C.2.

Westminster Industries, Ltd. 346,809.—Private company. Capital £2,000 in 2,000 shares of £1 each. To carry on the business of wholesale and retail chemists, druggists, importers and manufacturers of and dealers in pharmaceutical, medicinal, chemical, industrial and other preparations, etc. Subscribers: Wm. A. C. Henderson, 23 Chatterton Road, Finsbury Park, N.4, and Edmond C. Davis.

Monarchana Alcoil Na h-Eireann. 9,710 (registered in Dublin). Public company. Capital of £500,000 in 500,000 shares of £1 each. To manufacture and sell industrial alcohol; to acquire, erect and operate factories in Eire for the manufacture of industrial alcohol of every kind. Subscribers: John Leydon, Knocknaruss, Sutton, Co. Dublin; Arthur D. Codling, Walter Doblin, Sean O'Muinneacain, T. J. Flynn, R. C. Ferguson, J. J. McElligott.

Blau and Schindler, Ltd. 346,866.—Private company. Capital £2,000 in 2,000 shares of £1 each. Objects: To carry on the business of manufacturers, importers and exporters of and dealers in merchandise of all kinds, including timber, wood, oils, oil-seed, skins, hides, chemicals, salts, acids, gums, rubber, canvas, jute, flax, hemp, cotton, wool, leather, furniture, etc. Subscribers: Leslie Cork, 1-2 Finsbury Square, E.C.2; Mrs. Joseph L. Maguire.

Renco Products, Ltd. 346,802.—Private company. Capital £500 in 400 "A" ordinary shares of £1 each and 1,000 "B" ordinary shares of 2s. each. Objects: To carry on the business of manufacturers of and dealers in chemicals, gases and disinfectants of all kinds and in dyes, pigments, acids, drugs, powders, medicines, etc. Directors: Maurice D. Curwen, 174 Grove End Gardens, N.W.8; Herbert M. Gibson, Francis S. Ashdown. Registered office: 10-12 Copthall Avenue, E.C.2.

Resuflin, Ltd. 346,912.—Private company. Capital £6,000 in 4,000 7½ per cent. cumulative preference shares of £1 and 8,000 ordinary of 5s. To enter into an agreement with Ignatius Doff to purchase the rights of the registered trade mark "Resuflin," No. 550,490, dated August 9, 1934, Class 3, Chemicals; and to carry on and extend the business hitherto carried on by him; and to carry on the business of manufacturers of and dealers in chemicals, gases, drugs, medicines, etc. Directors: Ignatius Doff, Gladiator Works, 2a Keppel Road, Chorlton-cum-Hardy, Manchester; Reginald Hindley. Registered office: 227 Corn Exchange Buildings, Manchester, 4.

Chemical Markets

LONDON: There is not very much life in the chemical markets this week, the extended Christmas holidays having a marked influence on all sections. A reduction of £2 per ton in the price of caustic potash is reported, but elsewhere there have been no important price alterations. There is practically nothing to report in the coal tar section, both buyers and sellers appear to be marking time.

MANCHESTER: Extremely quiet trading conditions have been reported on the Manchester chemical market during the past week. In the closing days of last week before the holidays business was pretty well at a standstill, and generally inactive conditions were reported on the reopening of the markets on Wednesday of the present week. A good many chemical users are engaged in year-end stocktaking operations and this has had a markedly restrictive effect on the call for supplies. Not much activity will be experienced until about the second week of January. In the meantime, values have been maintained on a generally steady basis apart from some further slight easiness in one or two sections of the by-products market.

Company News

Dussek Bros. and Co., Ltd., report a profit for the year of £17,787 (£15,459, plus £834 profit on sales of investments). An ordinary dividend of 7 per cent. has been declared, making 10 per cent. for the year (8 per cent.).

Books Received

Chemie erobert die Welt. By Walter Greiling. Berlin: Wilheim Limpert-Verlag. Pp. 394. RM 7.50.

Vitamine und Hormone. By Dr. Franz Seitz. Part II. Leipzig: Verlag Von S. Hirzel. Pp. 205. RM.10.

Journal of the Electrodepositors' Technical Society. Vol. XIV 1937-8. London: Electrodepositors' Technical Society. Pp. 248. Members 15s. Non-Members 21s.

The Mineral Industry of the British Empire and Foreign Countries. Statistical Summary 1935-37. London: Imperial Institute, H.M. Stationery Office. Pp. 454. 7s. 6d.

The Phase Rule and Its Applications. By Alexander Findlay. 8th Edn. Revised with the assistance of A. N. Campbell. London: Longmans, Green & Co. Pp. 327. 12s. 6d.

German Grammar for Chemists and Other Science Students. By John T. Fotos and John L. Bray. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Ltd. Pp. 323. 11s.

Handbook of Chemical Microscopy. By Emile Monnin Chamot and Clyde Walter Mason. Vol. 1. 2nd Edition. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Ltd. Pp. 477. 22s. 6d.

Chemical and Allied Stocks and Shares

AS the Stock Exchange was open for business only on a few days this week the market in industrial and other shares has been inactive and the amount of business was not sufficient to permit any definite trend to develop.

Imperial Chemical ordinary units have remained around 30s. This compares with a highest price of 35s. 3d. recorded in 1938, but at one time they were down to 26s. 3d. Similar wide fluctuations have been recorded by the majority of leading industrial shares in 1938, and in fact shares of companies connected with the chemical and allied trades have shown a relatively steady tendency throughout the year. In the case of Fison, Packard and Prentice extreme prices have been 40s., and 32s., and at the time of writing the quotation is 38s. 9d. Turner and Newall now 75s. 9d. xd, were up to 88s. 1½d. at one time during the year, but they have been down to 63s. 9d. Lever and Unilever ordinary have also fluctuated rather widely in the past twelve months, movements having been between 40s. 7½d. and 27s. 6d., which compares with the current price of around 36s. 3d.

It will be seen that in most cases share values at the end of 1938, although considerably below their highest levels reached in the year are above the lowest points touched. Market sentiment is, in fact, tending to benefit from hopeful views as to improvement in general trade conditions in the new year, although it is realised that, in existing circumstances the trade outlook will continue to be influenced a good deal by developments in international political affairs. At the moment chief hopes are attached to anticipations that industrial recovery in America will be accelerated, because conditions in the U.S.A. usually have a very important influence not only on international trade, but on the trend in commodity and metal prices.

Towards the end of last week there was more activity in shares of steel and cement manufacturing concerns owing to the increased demand for steel and cement arising from the A.R.P. plans. In recent weeks cement shares were a weak market following reports of increasing competition in the trade, but Associated Cement ordinary units and various other cement shares have improved in price since the new A.R.P. scheme was announced. Associated Cement ordinary units are 67s. at the time of writing, which, however, compares with 67s. 6d. a week ago. In this case extreme prices in 1938 were 88s. 9d., and 66s. 9d. Shares of steel manufacturers have improved on the week. Dorman Long, whose extreme prices in 1938 were 34s. 3d. and 16s. 3d., are 24s. 9d. at the time of writing, which compares with 24s. a week ago, while on balance for the week United Steel have improved from 22s. 9d. to 23s. 6d., and Baldwins from 5s. 7½d. to 5s. 10½d. The demand for steel for A.R.P. structures is regarded as of considerable importance because it will come at a time when steel prices have been reduced and when the maintenance of the profits of steel producers at a favourable level may depend on whether production records an increase during the next six months or so.

Boots Drug at 39s. are virtually the same as a week ago. They were up to 50s. 4½d. earlier in 1938, but were down to 33s. 9d. at one time. Sangers at 21s. 9d. xd, and Timothy Whites and Taylors at 23s. 1½d. are also unchanged on the week. A slightly better price has ruled for Imperial Smelting ordinary shares, and Tube Investments ordinary at 85s. have also moved in favour of holders. Leading oil shares have shown an uncertain tendency, the disposition still being to await the impending interim dividends of the "Shell" and Royal Dutch companies.

Metallurgical Section

July 2, 1938

Current Topics

Non-Ferrous Metals Research

IT is expected that the new building of the British Non-Ferrous Metals Research Association in London will be equipped and in service early in 1939. At present more than sixty workers are crowded in the old building and much advantage to research and development work will be gained by expansion into double the space and by the provision of additional equipment. The 18th annual report of the Association states that during the year more than £20,000 was spent in the purchase of property, consuming all the year's savings and more than half of the accumulated reserve. Not less than a further £25,000 is likely to be required—nearly all before the end of 1938—in order to complete the new building, to make alterations to the old building, and to provide new equipment. Research activity will increase when the extensions are taken into use and ordinary expenditure will possibly overtake the present rate of income of about £30,000 a year from all sources. Further growth of membership is needed for a steady advance in activities and usefulness.

The Association is now co-operating with the Electrodepositors' Technical Society in drafting technical clauses for specifications for electrodeposited coatings. Substantial expenditure at Woolwich on electrodeposition research, and on development work in this field both at Woolwich and at the present London headquarters, justifies the Association's claim to be regarded as research association for the electrodeposition industries. Support from these industries has notably increased in recent years, but there are still many concerns which benefit from this work and which have not yet joined the Association.

Sixteen Major Researches

SINCE the period covered by the previous report, experimental work has been carried out on sixteen major researches, fourteen in the Association's laboratories and two extramurally. One investigation has concerned the use of copper pipes in conjunction with galvanised hot-water tanks in domestic systems. Corrosion tests on zinc coatings, differing in weight and relative proportions of outer zinc to alloy layer, are being continued in an experimental hot water system and are approaching a stage at which some interesting results should be forthcoming. Work on the electrodeposition of metals has been devoted largely to the study of bright nickel plating, with the object of determining the basic factors causing brightening and of investigating the properties of bright nickel deposits produced from known solutions. An endeavour to correlate brightening action with some specific property of the addition agents which produce this effect, should lead to an understanding of the mechanism of bright plating, facilitating control of solutions and the development of more satisfactory bright plating processes. Results capable of useful practical application arise in work of this kind and patents have been applied for covering two such developments. Work on the acid tin plating bath has done much to clear up the difficulties in this method of electrodeposition of tin. An improved solution has been developed which enables smooth, ductile, protective deposits to be produced. Further work has confirmed the satisfactory character of this bath when used for long periods, and the possibility of adapting it to give bright deposits is being considered.

The Institute of Welding has appointed a representative Welding Research Committee, under the chairmanship of Sir William Larke, which is undertaking a comprehensive series of researches on this particular subject and has invited the British Non-Ferrous Metals Research Association to co-operate in work on the weldability of non-ferrous metals. The proposal that such work should be undertaken as one of the Association's major researches was accepted by the Institute, which will provide a substantial part of the cost. The sub-committee has already taken steps to collect information from concerns interested in the welding of non-ferrous metals, in order to ascertain what are regarded as the more pressing problems, and has chosen the question of the effect of purity of the metal welded on weldability and on the properties of welds for first investigation. A review of the subject of the welding of non-ferrous metals and alloys will be prepared and will include information drawn from the replies to a questionnaire as well as published information.

Swedenborg's Treatise on Copper

THE annual report of the Non-Ferrous Metals Research Association also makes mention of one particular contribution to knowledge such as an industrial research body is seldom able to make. Some years ago the Association had reason to refer to various sections of Swedenborg's famous treatise on copper, usually known by its abbreviated Latin title "De Cupro." In spite of the importance of this work to metallurgists, it was only available in the original Latin edition published in 1734. Inquiries, however, led to the discovery of a manuscript English translation in the possession of the Swedenborg Society, in whose strong room it had been kept for thirty years, unknown, not only to the public generally, but also to those who are specially interested in the history of metallurgy. The Swedenborg Society gave permission for reproduction, and the British Non-Ferrous Metals Research Association is now able to supply mimeographed copies. This treatise by Swedenborg gives an account of the smelting and refining of copper as practised in many countries in his time, notes relating to the production of brass, the nature of copper ores and their assaying, and many other matters concerning copper and its alloys.

British Open-Hearth Data

THE Open-Hearth Committee, appointed in 1930 by the Iron and Steel Industrial Research Council, to investigate the factors involved in open-hearth steelmaking practice with a view to improving plant and furnace efficiency, contributed a useful report on British open-hearth data at a Symposium on Steelmaking, held on the occasion of the annual meeting of the Iron and Steel Institute. This report presented a survey of British open-hearth practice as made by the Committee and set out the distinctive features of British practice as a whole. Of the total steel production in 1937, 92 per cent. (11,939,200 tons) was made in the open-hearth furnace; acid open-hearth steel amounted to 17.5 per cent. (2,260,900 tons); basic open-hearth, 74.5 per cent. (9,678,300 tons). The relative proportion of basic to acid open-hearth steel has increased consistently since 1913. The number of open-hearth furnaces (acid and basic) used in producing 12 million tons of steel in 1937 was 344. Furnaces, however, differ widely for different plant and in different districts, depending on the process used, the proportion of scrap, the character of the steel, etc., and in order to obtain figures which could be regarded as representative of British practice, particulars were obtained from members of the British Iron and Steel Federation concerning 31 open-hearth furnaces working under widely varying conditions and producing different qualities of steel. These furnaces represented extreme variations which occur in plant design and operation.

Operating Efficiency of Furnaces

FOR the first time a basis of measurement for determining the operating efficiency of any open-hearth furnace or of comparing the operating efficiencies of furnaces working under widely varying conditions has been established. For furnaces making ordinary commercial steels, an average laboratory performance figure of 2.0 lb. of steel per hour per therm can be expected in the case of fixed furnaces, and 1.6 lb. per hour per therm for tilting furnaces. The large tilters show the lowest performances of the furnaces examined, largely on account of the prolonged period of refining required with the high percentage of hot metal used.

In furnaces of normal port design, high gas: air velocity ratios are desirable to give optimum performances; to obtain an adequate ratio the area of the air port should be at least six times that of the gas port. Where adequate gas: air velocity ratios are obtained, conventional designs of port have given results as good as special constructions. Whilst the relative hearth area should be large in high-scrap processes, an increase of hearth area must be considered in close conjunction with port design and flame direction. In processes using a high percentage of hot metal of high metalloid content, the net heat of the bath reactions, plus that in the liquid metal, is approximately equal to the heat output in the steel and slag. Furnaces working such processes are, therefore, constructed with deeper baths and correspondingly reduced hearth areas. Basic hot-metal fixed furnaces give the highest rates of production per unit capacity, averaging 7.53 tons compared with 7.46, 6.49 and 5.78 tons per hour per 100 tons capacity for basic cold-metal fixed, acid cold-metal fixed, and basic hot-metal tilting furnaces, respectively.

Utilising Low-Grade Iron Ores

THE "Brassert" or "Paschke-Paetz" iron ore reduction process is to be installed in German plants in order to utilise low-grade domestic ores. Although two German engineers, Max Paschke and E. Paetz, are credited with the discovery of the acid smelting process in March, 1934, it appears that H. A. Brassert, a naturalised American citizen, first developed the process commercially. The iron smelting works at Corby, first to use the process on a large commercial scale in England, was built in 1934 under direction of the Brassert concern, and uses an ore containing only 28 per cent. iron. The process is important because ores high in silicic acid (20 to 30 per cent.) and low in iron content (25 to 35 per cent.) can be worked economically. The high content of silicic acid in the customary basic smelting procedure impairs the binding of sulphur with calcium in slag, requiring the addition of an extraordinarily large amount of limestone in the furnace charge for eliminating the highly harmful sulphur. Formerly, the only method available for overcoming the difficulty of an excessive silicic acid content of iron ore, aside from direct smelting by the basic process with concomitant excessive fuel costs, was a preliminary ore-dressing procedure whereby the silicic acid content was lowered and the iron content enriched. This method, however, offered distinct disadvantages in contemporaneous heavy losses of iron and phosphorus, which increased costs to such an extent as to render production by its means uneconomic.

The Brassert "acid" process avoids the disadvantages both of direct smelting by the basic process with concomitant heavy admixture of lime and high coke consumption and of preliminary ore-dressing with its losses of iron and phosphorus. It abandons the principle of desulphurisation of the iron in the blast furnace in preference for direct smelting of the ore, yielding an easily fusible acid slag, with removal of the sulphur from the pig iron only after tapping from the blast furnace by the application of sodium carbonate. The process thus avoids either the charging of especially dressed ore or the addition of very large amounts of lime required for binding the sulphur and neutralising the very high content of silicic acid. In contrast to the usual basic process, the Brassert acid process required only so much lime in the blast furnace that an easily fusible acid slag (with considerably larger content of silicic acid and smaller content of lime) results. In consequence, a markedly lower smelting temperature suffices. This, together with the reduced addition of lime, causing a smaller amount of slag, enables a considerable saving in consumption of coke, compared with the basic process for smelting high-silica-content ore. In addition, the productive capacity in pig iron of the blast furnace is augmented considerably.

Under the basic process, the poorer the ores smelted in the blast furnace, the higher is the consumption of coke. By the acid process, however, owing to the greater liquidity of the slag, the coke charge remains the same as for a mixture rich in iron. In the Brassert "acid" process, high sulphur-containing pig iron is desulphurised after tapping, and for reducing the costs of desulphurisation a mixture of lime splint and sodium carbonate in proper proportions is used. The treatment gives improvement in the quality of the pig iron or steel.

Physical Chemistry in Steelmaking

The Reduction of Oxides by Carbon

WITH our ever-increasing knowledge of the subject the physical chemistry of steelmaking has become of great importance in the operations of steel manufacture, and there are few sections of the industry to-day which have not benefited from the wider appreciation of the possibilities of this branch of applied science, said Dr. A. McCance in his paper on " The Application of Physical Chemistry to Steelmaking" presented at the Symposium on Steelmaking (Acid and Basic Open-Hearth Process) held in conjunction with the annual meeting of the Iron and Steel Institute, early in May.

Mass Action Principles

The first step in the application of physical principles to chemistry was undoubtedly the discovery of the law of mass action by the Norwegians, Guldberg and Waage, in 1867, but, like many other important discoveries, it remained unnoticed until it was independently discovered by van't Hoff (1877) in the course of his brilliant work on chemical thermodynamics. It is to the penetrating mind of le Chatelier (1912) that we owe the first application of mass action principles to steelmaking, when he used them to estimate the solubility of FeO in liquid steel and obtained a calculated value, 1.1 per cent., which is not very different from the most accurately measured value of to-day, namely, 0.94 per cent. Attention was drawn to the subject again in 1925, when a symposium on " The Physical Chemistry of Steelmaking " was held by the Faraday Society in London, and an active interest was aroused amongst metallurgists all over the world, which soon reflected itself in many systematic and important investigations, notably by Herty in America, and more recently by Körber in Germany.

Dr. McCance gave a brief survey of the basis underlying the development of this work, and drew attention to the more important conclusions which have a direct bearing on the practice of steelmaking by the open-hearth process.

Physical chemistry assumes that chemical reactions take place by interaction between the gases or vapours appropriate to each substance, and proceeds to deduce the behaviour of the system from the behaviour of the gaseous or vapour pressures on the assumption that they all obey the ideal gas law and its consequences, and in so doing the deductions are exact and rigorous. But when it is sought to link up the reacting pressures with the concentrations of the gas, it is unfortunate that no actual substances conform to the theory. If the concentrations are very small then the error introduced is of no moment, and results which are sufficiently exact can be obtained. But in any normal concentration wide discrepancies arise. The reason, of course, is that the ideal gas law assumes that the molecules comprising the gas are without effect on one another, but in reality there are complicated forces of attraction and repulsion coming into play between them which no one as yet has been able to unravel.

Variations in Activity

Fortunately, in dealing with the elements which are of importance in steel manufacture, the percentage under consideration is nearly always small, so that variations in the activity can be neglected, but in dealing with the higher concentrations or with slag reactions the position is otherwise, and great care must be exercised before drawing general conclusions from the results of experiments which may refer only to a limited range of composition.

An interesting example of this can be given in the reduction of manganese and silicon from acid slags. Körber and Oelsen (*Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung*, 1933, *15*, 271; 1936, *18*, 109) have examined over a wide range of composition, the two reactions which take place. They are:

$$FeO + Mn = Fe + MnO \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$FeO + \tfrac{1}{2}Si = Fe + \tfrac{1}{2}SiO_2 \quad \ldots\ldots\ldots\ldots \quad (2)$$

giving the mass-action constants:

$$FeO \,.\, Mn \,.\, K_6 = Fe \,.\, MnO \quad \ldots\ldots\ldots\ldots \quad (3)$$

$$FeO \,.\, \tfrac{1}{2}Si \,.\, K_7 = Fe \,.\, \tfrac{1}{2}SiO_2. \quad \ldots\ldots\ldots\ldots \quad (4)$$

The effect of Fe and FeO can be eliminated by dividing these equations, so that:

$$\sqrt{Si} = \frac{K_6 \,.\, Mn}{K_7 \,.\, MnO} \sqrt{SiO_2} \quad \ldots\ldots\ldots\ldots \quad (5)$$

Since the silica content of the slags was constant around 50 per cent., it is seen that the square root of the silicon content of the steel should be proportional to the ratio Mn/MnO. This is well borne out in the results of Körber and Oelsen. Up to a content of 1.5 per cent. of manganese the activities of both silicon and manganese are constant and equal to unity. Where higher concentrations are concerned, however, their activities are much reduced, and the same ratio plotted for manganese contents up to nearly 80 per cent. departs very materially from the straight-line law, very far from the truth if extended to the range of the second series.

This illustration draws attention to a method which is of great use when dealing with equilibrium reactions. If more than one chemical reaction is possible, and one of these reactions is in equilibrium, then all of the other reactions are in equilibrum also. Consequently, the constants for an unknown reaction can be obtained by the multiplication or division of the constants from two known ones. Thus, from two known equations (1) and (2) above, the results for a third equation, the deoxidation of manganese oxide by silicon, has been obtained. By the use of a fourth the results for a fifth could be got and, indeed, the chain could be extended indefinitely.

Selective Reduction

In the solid state the oxides of most metals are reduced by carbon with the production of a mixture of carbon monoxide and carbon dioxide. If the temperature is above 1,000° C. at atmospheric pressure then the proportion of CO_2 formed is so small that it can be neglected and only the monoxide reaction taken into account. What then takes place is:

$$MeO + C = Me + CO, \quad \ldots\ldots\ldots\ldots \quad (6)$$

where Me stands for the metals such as Fe, Mn, $\frac{1}{2}$Si, etc. The pressure of the CO produced is a measure of its concentration, and the equilibrium constant is:

$$K = \frac{Me \,.\, Pco}{MeO \,.\, C} \quad \ldots\ldots\ldots\ldots \quad (7)$$

but since the concentrations of all the solids are taken as unity:

$$\log K = \log Pco. \quad \ldots\ldots\ldots\ldots \quad (8)$$

For FeO, MnO, SiO_2 and Al_2O_3 the experimental values for log *P*co can be plotted against $1/T$. When the pressure of CO exceeds one atmosphere the oxides will be reduced and the temperatures at which this occurs are as follows:—

FeO.	MnO.	SiO_2	Al_2O_3.
740° C.	1380° C.	1600° C.	1950° C.

This selective reduction at progressive temperatures is the basis of the interesting analytical method proposed by Reeve for determinating the amounts of these oxides present as inclusions in steel.

These same reactions can also take place in liquid steel, in which the reactants are soluble, with the exception possibly of SiO_2 and Al_2O_3. The volume mass effect of each will then vary, however, in proportion to the amount dissolved. In the

case of the insoluble constituents SiO_2 and Al_2O_3, their mass effect will still continue to be unity, since the reaction will not be influenced by the quantity which is present. The amount of iron also will not be greatly affected by any likely variations in the dissolved carbon and FeO, so its mass can be assumed to be constant, as can the pressure of CO, which cannot exceed the equivalent of one atmosphere without the excess escaping from the bath.

In solution the equilibrium constant refers then to two variables only, the iron oxide and the carbon, and it becomes:

$$C \times FeO = \text{constant.} \quad \ldots\ldots\ldots\ldots \quad (9)$$

Attempts to measure the value of this constant have been made by Kinzel and Egan (*American Institute of Mining and Metallurgical Engineers*, 1929, *Technical Publication No.* 230) and Vacher and Hamilton (*Transactions of the American Institute of Mining and Metallurgical Engineers*, 1931, *95*, 124), whose value of 0.011 at 1620° C., using weight percentages, is generally accepted.

Reaction (9) is of fundamental importance in steelmaking. In the open-hearth furnace, the bath after melting is high in carbon, and additions of iron ore are added. These dissolve in the slag, increasing its FeO content, an increase which is communicated to the FeO content of the bath with which it is in contact. The ratio:

$$\frac{\text{FeO in metal}}{\text{FeO in slag}} \quad \ldots\ldots\ldots\ldots\ldots \quad (10)$$

is known as the partition coefficient, L_{FeO}, and for practical purposes can be taken as a constant depending only on temperature. In a pure FeO slag the partition coefficient will be proportional to the solubility; for other slags the partition coefficient will require to be multiplied by the ratio of the density of the slag to that of pure FeO, so as to reduce weight percentages to equivalent volume concentrations.

Corrections for Density

For example, the densities of MnO and FeO are 5.40 and 5.745, and of their orthosilicates 4.043 and 4.296, so that the density ratio silicate/oxide is the same for both, namely, 0.75. One must be content with the densities at ordinary temperatures owing to the absence of any figures for the fused materials. At 1600° C. the solubility of FeO is 1.48 per cent., giving a partition coefficient in percentages of 0.0148. In MnO-FeO silicate mixtures the equivalent value will be $0.0148 \times 0.75 = 0.0111$, and for FeO added to $2CaO.SiO_2$ slags the corresponding value is $0.0148 \times 0.57 = 0.0085$. That found by Körber (*Zeitschrift für Elektrochemie*, 1937, *43*, 457) was 0.0095 as a mean from both types of slag. The partition coefficients at other temperatures can be estimated from the FeO solubility (Körber, *Stahl und Eisen*, 1932, *52*, 135). For all practical purposes the mean correction for density can be taken as 0.70 for both silicate and lime slags, so that at any temperature:

$$\frac{\text{FeO in metal}}{\text{FeO in slag}} = 0.70 \times \frac{\text{Solubility of FeO}}{100} \quad \ldots\ldots \quad (11)$$

A question arises here regarding the effect of Fe_2O_3 which always accompanies FeO in open-hearth slags. Under an atmosphere containing free oxygen a portion of the FeO is converted to Fe_2O_3. The amount is controlled by the equilibrium relations between the three, but complications are introduced by the combination of FeO with Fe_2O_3 to form Fe_2O_4, by the affinity of CaO for Fe_2O_3 to form ferrites, and by the affinity of SiO_2 for FeO to form silicates. These interdependent effects have been the subject of an important study by Hay. Under an atmosphere of constant oxygen content an increase in temperature reduces the concentration of Fe_2O_3, as does an increase in the silica content of the slag, while the presence of CaO naturally favours the production of ferrites and makes the ratio of Fe_2O_3 to FeO greater.

Ferric oxide is reduced when it comes in contact with the liquid steel surface, so the content in open-hearth slags is constantly changing, being increased at the slag-gas interface and reduced again at the slag-metal interface. In this way it acts as a carrier of oxygen, and its success in this rôle is largely controlled by the fluidity or viscosity of the slag. The effective concentration of Fe_2O_3 in such slags for chemical equilibrium is assumed by Herty, Christopher, Freeman and Sanderson (*Mining and Metallurgical Investigation*, 1934, *Co-operative Bulletin No.* 68) to be equal to 1.35 times that of the same molecular concentration of FeO.

An Equivalence Formula

Schenck (*Archiv für das Eisenhüttenwesen*, 1930, *3*, 572) has also examined this point and concludes that neither Herty's basis not the basis of calculating the FeO on the total iron is correct. He elaborates an equivalence formula based on the presence of calcium ferrites in a dissociated form which groups the experimental results more consistently, but in the absence of more accurate experiments it is questionable whether any advantage is gained by this complication. The quantity of Fe_2O_3 present in the slag definitely follows the free lime, or, alternatively, the acid constituents, as was shown by Whiteley (*Transactions of the Faraday Society*, 1925, *21*, Part 2, 249). It would appear that it does not depend on the percentage of FeO. Gas oxidation and ore oxidation are consequently two independent actions, which should be watched separately if the state of oxidation of the bath is to be accurately assessed. A knowledge of the partition coefficient for MnO has so far not been obtained. Owing to its chemical interaction with iron, a direct determination does not seem possible and an indirect calculation seems the only method of approach.

If the product FeO × C at any instant is greater than the equilibrium value, then the carbon is oxidised at a rate which is estimated by the mass action relation:

$$\text{Rate of removal of carbon} = k_1 \times C_{FeO} \times C_c - k_2 \times C_{Co}, \quad \ldots (12)$$

where k_1 and k_2 are the reaction velocities. If the FeO concentration is kept constant (i.e., by feeding iron ore in small and regular quantities) it has been shown that log C_c plotted against the time gives a straight line. (McCance, *Transactions of the Faraday Society*, 1919, *14*, 216). As the carbon and FeO are removed by interaction, the rate of removal becomes slower and slower and would finally cease if sufficient time were allowed.

This principle has been used by Herty (*Metals and Alloys*, 1930, *1*, 883) to obtain the equilibrium constant from the working of a basic charge. Samples were taken during the boiling period and analysed for oxygen by the aluminium method and for carbon, whilst the rate of carbon removal was obtained graphically from the carbon-time curve. The results obtained were as follows:

Temperature, ° C. ...	1570-1590	1590-1610	1635
K	0.012	0.010	0.006

Heat of Reaction

No systematic investigation of the FeO × C constant at various temperatures has so far been carried out. The heat of reaction at a temperature of 1,500-1,600° C. of the equation:

$$FeO + C = Fe + CO \quad \ldots\ldots\ldots \quad (13)$$

has been estimated by the author at 28.5 cal. Using this value and that of Vacher and Hamilton for K at 1620° of 0.011, the value at other temperatures can be expressed by the relation:

$$\log K = -\frac{6230}{T} + 5.246 \quad \ldots\ldots\ldots \quad (14)$$

In the solid state the pressure of CO from equation (13) increases very rapidly with the temperature. At the melting point of iron it is in the neighbourhood of 9,300 atmospheres, and theoretically this is also the pressure produced by the saturated solutions in iron of carbon and FeO which contain 5.50 per cent. and 0.95 per cent., respectively, provided that they do not interfere with one another's solubility when present together. Any excess of either constituent above the equilibrium value at any temperature will cause a rapid

reduction of the oxide and the liberation of an equivalent amount of CO gas. In mild steel containing 0.10 per cent. of carbon the equilibrium amount of FeO present at atmospheric pressure in the liquid bath (assumed to have a temperature of 1,620° C.) will be 0.11 per cent., and since K increases as the temperature falls there will be no tendency to react and thus to liberate CO gas down to the solidifying point.

The solid solubility of FeO has been variously estimated, but it can be taken as being less than that of the liquid. This fact the author believes, taken in conjunction with the reducibility of the different oxides, provides an adequate explanation of the causes which give rise to rimming steels. Rimming steels are produced when liquid steel is deoxidised with manganese only and no additions, or only very limited additions, of silicon or aluminium are used. When such steel commences to solidify in the mould, oxides in excess of the solid solubility will be rejected at the surface of separation between the solid and the liquid, and can be imagined as concentrating there in a thin layer. This concentration will immediately upset any previously existing equilibrium, and reaction will take place with the formation of carbon monoxide, which will readily escape to the surface.

The Solidification Point

The temperature of solidification being in the neighbourhood of 1,500° C., only FeO and MnO, of which the temperatures of reduction in the solid state are 740° and 1,380° C., respectively, can react in this manner. Sio_2 and Al_2O_3, which are assumed to be insoluble, have too-high reduction temperatures (1,600° and 1,950° C., respectively) to be reduced by carbon in this way. Silicon and aluminium kill steel because the products of deoxidation are no longer reducible by carbon at the solidification point of steel, and, equally, manganese is the only deoxidiser which can be used in the production of rimming steels, since its oxide can be so reduced.

If the ferrous or manganese oxide content of the liquid steel is reduced below the solid solubility point, it is obvious that no rimming action can take place. An excess of manganese or carbon can stop the rimming action, and in practice it is known that steels with more than 0.30 per cent. of carbon or 0.70 per cent. of manganese do not rim properly, if at all. The escaping CO takes with it its proportion of the carbon, and the solid rim has a lower carbon content than the average of the liquid steel from which it came. Each 0.01 per cent. drop in carbon is equivalent to a drop of 0.06 per cent. of FeO. For a 0.10 per cent. carbon steel the average carbon drop in the rim is 0.03-0.04 per cent., corresponding to 0.18-0.24 per cent. of FeO.

Nickel Silver

A Survey of Published Information

As a preliminary to researches which the British Non-Ferrous Metals Research Association has in hand, T. F. Pearson made a careful examination of available information on nickel silver alloys. The results of his survey are set out in B.N.F.M.R.A. Research Report R.R.A. 472, obtainable from the Association at Regnart Buildings, Euston Street, London, N.W.1., price 3s.

After a short introductory section, the specifications for nickel silver alloys issued in various countries are listed and discussed. Then follows a section devoted to the mechanical and physical properties of the alloys. Values for the mechanical properties in both cast and wrought forms and at various temperatures are noted, together with the endurance properties. Data on physical properties include thermal conductivity and electrical resistance, density, tarnish resistance, shrinkage and fluidity, etc. The various aspects of melting and casting are next dealt with. Some casting defects are mentioned, and there is a short account of sands and sand moulding. The effects of impurities on behaviour in casting and working and on properties then receive attention, the impurities considered including lead, tin, manganese, aluminium, iron, silicon, carbon, phosphorus, magnesium, sulphur, oxygen, antimony and arsenic. Finally there are accounts of the working of the alloys (rolling, extrusion, jointing, cleaning and finishing) and of the effect of annealing. A select bibliography of nearly 90 items is provided, reference to which is made throughout the text.

Plastic Strain in Metals

Annual May Lecture of Institute of Metals

Plastic strain in metals was approached from the point of view of a mathematician when Professor G. I. Taylor, F.R.S., delivered the 28th annual May lecture before the Institute of Metals. The lecturer said his interest in metals was first aroused on hearing Sir Harold Carpenter and Dr. Elam describe their discovery of the methods by which very large crystals of aluminium could be prepared. This led to collaboration with Dr. Elam in analysing the strain in large crystals when subjected to end load. Later a method of straining single crystals by compression was developed which produced very uniform strains.

The method used for analysis was to calculate from external strain measurements the "unstretched cone"; that is, the cone containing all directions in the crystal which are unchanged in length by the strain. The method was illustrated by means of a model in which the planes and directions of a cubic crystal constructed into the form of a hemispherical wire cage. This cage was mounted on gymbals and projected by an arc light on to a screen so that the properties of stereographic and other projections could be demonstrated. At the end of the lecture the bearing of experimental results obtained with single crystals on crystal aggregates was discussed. The fallacy of assuming that each grain in an aggregate can be treated as though its neighbours do not exist was pointed out, and it was shown that in a cubic crystal five out of the possible twelve modes of slipping must operate simultaneously in order that a crystal in an aggregate may be deformed so that its boundaries still fit in with those of its neighbours. Finally the complete solution for the case of an aggregate extended by direct load was described and the resulting predictions compared with experiment.

Tin-Base Bearing Metals

Service Life Under Severe Conditions

White bearing metals rich in tin have already a century of successful use behind them and researches are now proceeding to ensure that they maintain their reputation under the often more severe conditions of service that obtain to-day. In certain types of internal combustion engine where the loading is very severe white bearing metals have sometimes cracked and broken up. The study of these failures has led to modifications in design and operating conditions and further progress should follow fresh knowledge.

In a recent paper to the Institute of Mechanical Engineers, D. J. Macnaughtan, director of the International Tin Research and Development Council, discusses typical failures and the factors underlying them. Tests revealed the degree of stress in white metal linings on thin steel shells due to thermal expansion and contraction and showed to what extent the stress could be relieved by creep. Other probable causes of tensile stresses are discussed and the author considers at what temperature the fatigue properties should be compared in view of results obtained at room temperature and 150° C. with bearing metals containing additions of cadmium and lead. These experiments suggest that less than two per cent. of cadmium and no lead should be permitted in white bearing metals. This paper has now been published by the International Tin Research and Development Council, from whom copies may be obtained free of charge.

Some Recent Metallurgical Patents

Rustproofing Metals

A material for rustproofing metals, e.g., for browning gun barrels and gun parts, includes a liquid produced by nitriting an alkyl derivative of a cyclic alcohol by means of an acid and an inorganic nitrite and, after the reaction is complete, adding a solvent for the organic nitrite and filtering. The rustproofing material may consist of about 3 per cent. of the liquid so formed together with water and one or more metallic salts. In an example 2-methylcyclohexanol is mixed with sodium nitrite and water and to the mixture, which is agitated vigorously, a mixture of 1 part of pure sulphuric acid and 2 parts of water is added, the resultant liquid being cooled continuously until the reaction is complete. Methylated spirit is then added and the liquid is filtered. The filtrate may be mixed with a saturated solution of ferrous sulphate, a solution of antimony chloride, copper sulphate, and water to form a rustproofing material. The steel, etc., to be rustproofed is cleaned and polished with lime water before the material is applied. (See Specification 476,006 of Blackwell, Hayes and Co., Ltd., and C. L. M. Brown).

Lead and Lead Alloys

Lead, which may contain another element or elements, is treated with a flux containing a lead halide and a metal sulphide whereby the metal of the sulphide, which may in some cases be lead, enters the bath, and an element in the bath, or some of the lead itself, is extracted in the form of sulphide. Elements such as bismuth, arsenic, antimony, silver, and tellurium may be introduced into lead; elements such as lithium, sodium, magnesium, aluminium, potassium, calcium, zinc, strontium, and tin may be removed; and some elements such as nickel, cadmium, copper, and selenium may be either introduced or removed. The sulphide may be used in the flux in the form of a sulphite ore or residue. (See Specification 476,223 of Goodlass Wall and Lead Industries ,Ltd., and W. T. Butcher).

Treating Iron Ores

In a blast furnace process in which iron ores or agglomerates containing substantial amounts of zincs are smelted with the addition of alkali or akaline earth chlorides, the waste gases are passed successively through dry and wet separators of such relative size and number that the heavy iron-containing dust is collected in the dry separators and a product rich in zinc and poor in iron is obtained in the subsequent wet treatment. (See specification 480,566 of Hutten-Werke Siegerland Akt.Ges.).

Precipitating Precious Metals

Porous carbon is activated for use as a gold precipitant by impregnating it with mercury or zinc in the form of vapour, which is then condensed therein. After use as a precipitant, the carbon is burnt off and the residue smelted. The activating metal may be removed by distillation or solution in acid. The addition of lead acetate or nitrate is not required in the precipitating process. (See Specification 476,458 of E. L. Francis (Tube Gold Extractors (Proprietary), Ltd.).

De-Phosphorising Steel

Steel is de-phosphorised and de-sulphurised by pouring the molten steel into a receptacle, a mixture of one or more alkaline carbonates and an oxide, such as barium dioxide, which is energetically oxidising with respect to the phosphorus being introduced into the jet of metal while the latter is being poured, the mixture evolving gases or vapours in a quantity sufficient to produce a violent agitation and seething. To prevent the cooling of the steel during the reaction, the mixture may also contain a reducing agent or exothermically acting mixture containing reducing agents such as an alumino-thermic or silicothermic mixture. (See Specification of 476,483 of Soc. D'Electro-Chimie, D'Electro-Metallurgie, et des Acieries Electriques D'ugine).

Coating Metals

Aluminium or an aluminium alloy is coated with a thin layer of iron by immersion in a bath containing ferrous chloride hexahydrate and commercial, 35-38 per cent., hydrochloric acid, preferably in equal proportions, at a temperature above 80° C., preferably 92-95° C. It is then electroplated first with a thin layer of nickel, nickel-copper or other nickel alloy and then with a thicker layer of chromium. (See Specification 476,720 of Dr. Finckh, Ges.).

Iron and Steel Alloys

Iron, steel, and ferrous alloys are produced by treating a molten pig iron to which alloying ingredients or steel scrap may have been added, at a temperature of 1,600-2,000 °C., first with sodium sulphate and then with limestone, the treated metal then being cast. Before the treatment with limestone the molten metal may be re-heated to or above its original temperature. The alloying ingredients, e.g., nickel, chromium, or tungsten, may be melted with the pig iron or introduced in the solid or molten state into the molten metal before, or during treatment or after the treatment with sodium sulphate, etc. The iron etc., produced may be hardened by heating to 800-900° C., and quenching in oil or water. (See Specification 476,800 of G. W. Willis).

Hardening Iron Alloys

To moderate the hardening effect of a liquid used for quenching the surface of a heated iron alloy article, air or another gas, such as nitrogen or carbon dioxide, is introduced into the quenching liquid in the form of finely distributed bubbles. The air or other gas may be enclosed in the foam produced by adding a foam-former, such as soap, saponin or glycerine, to the quenching liquid and may be introduced into the liquid or the soap or solution by means of a water-jet pump. Instead of water chlorinated hydrocarbons such as carbon tetrachloride or trichlorethylene may be used as the quenching liquid. (See Specification 476,946 of I. G. Farbenindustrie).

Hard Alloys

In making hard alloys of the type comprising hard carbides of metals such as tungsten, tantalum, titanium, molybdenum, chromium, and vanadium, together with metals of lower melting point such as cobalt, nickel, and iron, the sintered product is cooled rapidly for example in about 4 minutes, in air or a gaseous atmosphere from the sintering temperature, which may be 1,400-1,700° C., to about 200° C. by being quickly transferred from the sintering furnace to a cooling chamber, which may be water-cooled, the blocks being maintained in a reducing or inert atmosphere while being transferred to the cooling chamber. The blocks are preferably packed in graphite powder in boats to prevent contact with the walls of the cooling chamber. (See Specification 477,181 of W. H. Hatfield and H. Burden).

Steel and Alloy Steels

Sulphurised free-cutting steel is produced by adding an intimate pre-formed mixture of manganese and sulphur to molten steel in the desired proportion according to the kind of steel to be produced. The manganese in the mixture may be replaced by iron, by another deoxidising metal or by another metal which is to be alloyed with the steel. Examples of such additions are cobalt, molybdenum, or ferro-alloys such as ferro-silicon, ferro-tantalum or ferro-vanadium. The manganese, etc., in the form of dust or finely-ground is stirred in the required proportion into molten thinly-fluid sulphur, and the product cast into slabs or pieces which may be coated with an envelope protecting them from oxidation, such as a coating of water-glass, or made of a reducing substance such as paper. (See Specification 477,294 of Neunkircher Eisenwerk Akt.-Ges. Vorm. Geb. Stumm).

Metallurgical Section

August 6, 1938

Current Topics

Properties of Niobium Metal

INVESTIGATIONS at the laboratories of the Siemens-Rohren-Werk on the properties of niobium have recently been directed towards establishing better knowledge of the chemical resistance of this metal. Niobium, it is pointed out, is very similar in general properties to tantalum, but gas-free niobium is more ductile than tantalum and can be more easily worked up into wires and sheets. Both metals, however, possess the property of absorbing gases at temperatures above 300° C., while the melting point of niobium, at 2,500° C., is about 350° C. below that of tantalum. The present investigations have shown that niobium is equal to tantalum with regard to its resistance to gases, up to the temperatures of 300° C. At ordinary temperatures, it shows no change whatever when submitted to the action of nitrogen, oxygen, steam, hydrogen, carbon monoxide or dioxide, sulphur dioxide, hydrogen sulphide or chlorine. At about 400° C., niobium burns in air with the formation of the pentoxide, a pale yellow powder. It reacts with hydrogen at higher temperatures, to form niobium hydride—a glass-hard material, but pure nitrogen does not react until temperatures are above 600° C., while carbon monoxide and carbon dioxide react at 1,200° C., with the formation of niobium carbide, a very hard body melting above 4,000° C. and insoluble in all acids.

According to Dr. K. H. Kreuchen (*Chemische Fabrik*, 1937, No. 41 and 42) niobium metal is available commercially in the same forms as tantalum, namely, as rods and wires, foils and sheets, and seamless tubing of certain sizes. The metal shows good resistance to materials other than hydrofluoric acid, concentrated sulphuric acid, concentrated hydrochloric acid and strong alkalies. Its instability seems to be due, in nearly every case, to the action of hydrogen and the formation of the brittle hydride.

Aluminium Production in Greater Germany

THE record aluminium output in Germany during 1937 of 127,500 metric tons was apparently insufficient to meet all of Germany's requirements, and the importation of 3,650 tons of raw metal and 3,500 tons of scrap became necessary. Only 1,334 tons of raw metal was exported. It is said that in 1938 production may reach 175,000 or 180,000 tons. No new aluminium producing plants have been established in Germany in recent years, and the expanded production has been entirely due to marked enlargements in capacity of existing plants. No data is available showing individual plant details such as production, capacity, processes employed, number of workers, etc. The German aluminium reduction plants of the Vereinigte Aluminium Werke A.G. are located at Lautawerke, Toging-am-Inn, and Grevenbroich (Niederrhein); Aluminiumwerke G.m.b.H., has works at Bitterfield; Aluminium G.m.b.H., at Rheinfelden (Rhein). The Vereinigte Aluminium Werk is by far the largest producing company, reported to control around 75 per cent. of the national output of aluminium, and is completely Government-owned.

Aluminiumwerke (Bitterfield) is a joint subsidiary of the I. G. Farbenindustrie and the Metallgesellschaft, both of Frankfort-on-Main, each company controlling 50 per cent. of the capital stock of the subsidiary aluminium company. Aluminium (Rheinfelden) is a newly created German subsidiary of the Swiss aluminium concern, Aluminium Industrie, of Newhausen, formed in 1937 for operating the Swiss company's plants in Germany which were previously operated direct. The aluminium industry of greater Germany, now incorporating Austria, has now been enlarged by the addition of two small producing plants situated at Steeg and Lend in Austria, both of which combined are understood to produce between 4,000 and 5,000 metric tons of aluminium per year.

Cooling Rate of Iron Alloys

AT the National Bureau of Standards in the United States, T. G. Digges has been making experiments to determine the rôle that carbon plays in controlling the hardenability of high purity iron-carbon alloys and plain carbon steels. To accomplish this a series of high purity iron-carbon alloys and two series of plain carbon steels were prepared, in which the chemical composition of each series was kept constant except for the amounts of carbon present. The preparation of these alloys and steels and their hardening properties for various conditions are discussed in the May issue of the *Journal of Research*, where it is reported that analyses made on specimens of the iron-carbon alloys showed that they contained negligible amounts of impurities, the value for all those determined being only about 0.03 per cent. by weight.

In these investigations the critical or slowest cooling rate for which the steel will be fully hardened, was determined under controlled conditions for both high purity iron-carbon alloys and carbon steels. This critical cooling rate was then used as an index of the hardenability of these alloys and steels. It was shown that the carbon steel, containing about 0.80 per cent. of carbon, was deeper hardening than the higher carbon steels, only for conditions where the hardenability of the steels was influenced by factors such as variations in grain size or when all carbon was not in solution at the time of quenching. Where average grain size was constant and all carbon was in solution at the time of quenching, the critical cooling rate decreased continuously as the carbon content increased for the iron-carbon alloys and also for the steels. In other words, the iron-carbon alloy containing the highest

amount of carbon (1.21 per cent.) had the greatest depth of hardening of this entire series of alloys, and likewise the carbon steel containing the highest amount of carbon had the greatest depth of hardening of that entire series. To utilise the full hardening power of the alloys and steels, it was necessary to heat them to temperatures sufficiently high to insure the complete solution of the carbon.

A comparison of the hardenability of these high purity iron-carbon alloys and plain carbon steels showed that the former were comparatively shallow hardening. This difference in hardenability was due to the higher manganese content of the steels. Another important feature brought out in these experiments concerned the influence of the dissolved carbon content of the alloys and steels at the time of quenching on their hardenability. It has been usually believed that plain carbon steels containing about 0.80 to 0.90 per cent. of carbon have slower critical cooling rates, i.e., are deeper hardening, than similar carbon steels containing either lower or higher amounts of carbon.

A Museum of the Use of Tin

THE International Tin Research and Development Council has been making a systematic collection of specimens illustrating the scope of the applications of tin and of the Council's researches, as one means of approach to the problem of providing information on tin and products containing tin. The items in the collection are available for demonstration at exhibitions and trade fairs, for lectures to scientific societies, and for instructional purposes at teaching institutions. The range of applications of tin in industry is so exceptionally wide that there is necessarily a great diversity of products in the collection. All the principal applications are represented, and there are also many less familiar and novel products. In many cases the manufacture of an article have generously given exhibits which show their product at each successive stage of manufacture, as, for example, in the case of the lithographing of tinplate. Researches are represented by specimens, photographs and photomicrographs, obtained in the course of the investigations; there are also about 450 lantern slides available. Other exhibits have been specially prepared to illustrate some particular discovery.

Among the more striking exhibits of this type are photographs dealing with the investigation of the tin-iron alloy formed at the surface of steel during tinplate manufacture; actual specimens of tinplate subjected to the hot-water test for porosity; and tinned steel cleaned by ordinary detergents contrasted with the same material cleaned by the improved detergent developed in the Council's laboratories. Electrodeposition exhibits include specimens of bronze plating, and others designed to show the high throwing-power of the alkaline tin plating bath. Other exhibits show how decorative designs can be produced on pewter by anodic treatment, and the decreased porosity of tinplate after superimposed electrodeposition of tin. Indexed and arranged in glass-topped, transportable show-cases, they are permanently on view at the London office of the Council.

The Effect of Copper on Some Alloy Steels*

By
R. HARRISON, B.Sc.

COPPER is now commonly added to stuctural steels in small amounts, 0.2—0.5 per cent., to increase their resistance to atmospheric corrosion, but in spite of the existence of a comprehensive survey by Gregg and Daniloff ("Alloys of Iron and Copper") very little information is available on the effects of larger amounts of copper on the mechanical properties.

The present investigation was intended to form a preliminary survey of the possibiity of utilising the temper-hardening effect of copper, in steels containing other alloy elements, to develop a structural steel of high yield strength. It was found, however, that copper might prove to be a useful alloy element in steels used in the oil-quenched and tempered condition, and the mechanical properties after these treatments were also examined.

The compositions of the steels used are given in Table I, and details of manufacture and forging in Table II. The maximum temperature of reheating for rolling or forging was limited to 1050° C. to avoid melting any metallic copper formed in the scale and the consequent possibility of intercrystalline penetration. No difficulty was experienced in working the steels listed in Table I, but an attempt to roll 0.5 per cent. chromium steels containing more than 5.0 per cent. of copper with low carbon or more than 4.0 per cent. of copper with medium carbon contents, resulted in the ingots bursting at the first pass.

The response of the steels to the temper-hardening treatment was followed by investigating the change of hardness undergone by small specimens air-cooled from temperatures ranging from 700° to 950° C. and subsequently reheated at temperatures between 400° and 700° C. for various times.

Among the 0.5 per cent. chromium steels, after normalising from 800° C. the maximum increase in hardness occurred in the low-carbon series, and the maximum hardness attained in any of the steels examined was not affected to an important extent by a variation in the tempering temperature between 450° and 550°, though the time of heating necessary to give the maximum hardness was shorter with the higher tempering temperature. An increase in the copper content from 1.6 to 4.0 per cent. made no difference to the extent of the temper-hardening as measured by the increase in hardness on tempering. No corresponding change in hardness occurred in a similar chromium steel free from copper.

An increase in the normalising temperature above 800° C. led to a partial air-hardening of the chromium-copper steels containing over 3 per cent. of copper, but the effect was less pronounced than in the more strongly air-hardening nickel-chromium steels with 1-2 per cent. of copper. As the normalising temperature was increased the temper-hardening effect was gradually masked by the softening due to tempering which succeeded air-hardening. The air-hardening effect in the nickel-copper steels was somewhat similar to that in the chromium-copper steels, but the maximum temper-hardening in the nickel-copper steels was considerably less than in the chromium-copper or nickel-chromium-copper steels. In these, as in other instances, the temper-hardening effect reached its maximum before the copper content exceeded 2 per cent.

* Abstract of a paper presented at the annual meeting of the Iron and Steel Institute.

The steels thus fell into two groups, according to whether the effect of temper-hardening or of air-hardening predominated under the conditions of treatment, including the size of specimen treated. When pronounced air-hardening had occurred, however, as in the nickel-chromium-copper steels, the fall of hardness on tempering was checked, and the hardness remained constant or rose slightly on continued tempering.

The behaviour of low-carbon copper-chromium steels containing 1.6 per cent. of copper was similar after oil-hardening from 950° C. to that after air-cooling from 950° C. With 4 per cent. of copper, however, the steel was slightly harder after oil-quenching (280) than after air-cooling (260), and, moreover, hardened further to 320 after tempering, whereas the air-cooled specimen softened continuously. This greater tendency to temper-hardening after oil-quenching may possibly be due to the retention of rather more copper in solid solution when the cooling through the eutectoid transformation has been more rapid.

It was clear that in the treatment of small pieces the temper-hardening effect was not likely to give as hard a product as one which had received the usual treatment of quenching and tempering. The behaviour of 3¼-in. diameter specimens of selected steels was therefore investigated, the initial cooling being done on specimens 6 in. long, smaller pieces being cut from the mass for tempering. The steels used were Nos. 12, 13 and 21.

The chromium-copper steels showed temper-hardening after air-cooling from 800° C., but the effect was masked by some air-hardening when the normalising temperature was 950° C. In small sections the nickel-chromium-copper steel was sufficiently air-hardening to show a progressive softening after an initial air-cooling from 800° C., but in larger sections the temper-hardening tendency showed itself in maintaining the hardness at an almost constant value on tempering at 500° C.

Table I. Chemical Analyses of Steels Used.

Steel No.	Mark.	Carbon. %	Silicon. %	Manganese. %	Sulphur. %	Phosphorus. %	Nickel. %	Chromium. %	Copper. %
1	*MJD*	0·048	0·21	0·28	<0·005	0·021	...	0·50	1·62
2	*MJE*	0·040	0·24	0·28	0·021	0·027	—	0·51	2·13
3	*MJF*	0·054	0·24	0·39	0·021	0·021	...	0·52	3·14
4	*MJG*	0·040	0·19	0·40	<0·005	0·022	...	0·51	4·02
5	*NEC*	0·040	0·15	0·28	0·011	0·020	...	0·49	5·20
6	*MJH*	0·29	0·26	0·40	0·009	0·026	...	0·51	1·54
7	*MJJ*	0·28	0·35	0·47	0·009	0·020	...	0·48	2·06
8	*MJK*	0·23	0·25	0·32	0·039	0·027	...	0·53	3·15
9	*MJL*	0·20	0·19	0·43	0·021	0·018	...	0·49	4·15
10	*NEB*	0·24	0·20	0·31	0·006	0·020	...	0·47	4·05
11	*NED*	0·24	0·19	0·36	0·008	0·022	...	0·88	4·00
12	*NYX*	0·25	0·18	0·24	0·008	0·023	...	1·47	2·14
13	*NYX*	0·32	0·18	0·23	0·009	0·023	...	1·42	2·12
14	*OGM*	0·32	0·17	0·55	0·015	0·028	2·24	...	1·19
15	*OGH*	0·35	0·17	0·46	0·016	0·025	2·17	...	2·10
16	*OGJ*	0·29	0·15	0·51	0·015	0·025	2·25	...	4·23
17	*OGN*	0·30	0·18	0·55	0·020	0·026	2·05	0·63	1·19
18	*OGK*	0·31	0·17	0·52	0·020	0·024	2·07	0·61	2·20
19	*OGO*	0·33	0·16	0·62	0·016	0·025	2·08	1·15	1·18
20	*OGL*	0·34	0·20	0·60	0·022	0·024	2·15	1·18	2·33
21	*NYZ*	0·28	0·13	0·18	<0·005	0·019	2·15	1·41	1·98
22	*QZN*	0·30	0·28	0·44	<0·005	0·025	3·50	0·90	...
23	*QZO*	0·27	0·21	0·38	<0·005	0·025	2·55	0·80	1·00
24	*QZP*	0·26	0·25	0·44	<0·005	0·025	1·55	0·85	2·03
25	*QZQ*	0·27	0·26	0·43	<0·005	0·030	...	0·85	3·40
26	*OUO*	0·30	0·24	0·45	0·037	0·037	...	...	...
27	*OVK*	0·27	0·24	0·60	0·035	0·040	...	...	1·06
28	*OXP*	0·26	0·23	0·62	0·034	0·039	1·40	...	...
29	*OXW*	0·26	0·22	0·72	0·036	0·040	1·49	...	1·00
30	*PAB*	0·27	0·23	0·66	0·036	0·039	1·54	0·61	...
31	*OZU*	0·31	0·22	0·70	0·037	0·038	1·36	0·48	1·02
32	*OUV*	0·30	0·24	1·21	0·034	0·043	...	...	...
33	*PJW*	0·27	0·21	1·48	0·037	0·040	...	...	1·05
34	*OXH*	0·29	0·21	1·90	0·036	0·041	...	...	1·00
*A**	...	0·31	...	0·46	...	...	...	0·66	...
*B**	...	0·29	...	0·46	...	...	...	0·67	0·50
*C**	...	0·27	...	0·52	...	...	...	0·62	1·06

* *Journal of the Iron and Steel Institute*, 1930, No. I., p. 209.

Table II. Sizes of Ingots and Forged Bars.

Steels Nos.	Type of Furnace.	Ingot. Weight lb.	Section.	
1–11	High-frequency	30	3 in. × 3 in.	1¾ in. × ½ in.*
12, 13, 21	High-frequency	60	4½ in. × 4½ in.	3¼ in. in dia.
14–20	High-frequency	12	2 in. × 2 in.	1⅛ in. × ½ in.
22–25	High-frequency	40	3¾ in. × 3¾ in.	1½ in. × ⅜ in.
26–34	Tropenas converter	100	4½ in. × 4½ in.	3¼ in. in dia.

* Rolled.

Mechanical Properties

The tensile properties were determined on test-pieces 0.357 in. in diameter, with a parallel portion 2¼ in. long, except in the case of steels Nos. 12, 13 and 21-25, for which a test-piece 0.564 in. in diameter with a gauge length of 2 in. was used. Limits of proportionality and yield points were determined by means of a Ewing extensometer, the yield point being taken as the load giving a permanent extension of 0.2 per cent. (0.004 in. on 2 in.). The elongation was measured on a gauge length of 1.26 in. ($L=4\sqrt{a}$). The notched-bar impact tests were carried out in a 120-ft.lb. Izod machine on 3-notch test-pieces of the B.S.I. standard form (45° V notch with a root radius of 0.25 mm. and 2mm. deep). All tests were taken in the longitudinal direction.

Chromium-Copper Steels. Carbon 0.05 and 0.20-0.29 per cent., Chromium 0.5 per cent., Copper 1.5-5.0 per cent. (*Steels* 1-11). In the low-carbon series, the properties in the as-rolled condition were remarkably good, a yield point of 32 tons per sq. in., with an Izod impact figure of 95 ft. lb. and good ductility, being obtained for the 1.5 per cent. copper steel. Increasing the copper content produced a small and irregular increase in the maximum load. In the medium-carbon series there was a marked increase in the tensile strength with increasing copper content, but the Izod figure fell from a maximum value of 29 ft.lb. to 3 ft.lb. at 4 per cent of copper.

The occurrence of air-hardening was shown in the results tensile tests made on specimens which had been normalised by heating for ½ hr. at 950° C. followed by cooling in air. In both series the interval between the limit of proportionality and the yield point increased progressively with an increase in copper content above 2.0 per cent. Very good Izod impact figures were obtained in the low-carbon steels containing up to 3 per cent. of copper, but with higher copper contents considerable scatter appeared. In the medium-carbon series the impact figure fell progressively from 35 ft.lb. to 5 ft.lb. at 4 per cent. of copper.

Air-Hardening of Low-Copper Steels

The low-copper steels, in which little or no air-hardening had occurred, were temper-hardened, an increase in the limit of proportionality, yield point and maximum load being accompanied by a fall in the elongation. Those steels which had been air-hardened by the normalising treatment softened on re-heating but the tempering effect did not appear to be complete in the medium-carbon series. The Izod impact figure was adversely affected by the reheating treatment; erratic results were obtained in the low-carbon series and the maximum value in the medium-carbon series was only 17 ft.lb.

The influence of copper on the mechanical properties of the medium-carbon series, after normalising at 800° C., was masked by the considerable range in the carbon content, which varied from 0.20 to 0.29 per cent. The maximum load, yield point, and limit of proportionality were each increased by approximately 18 tons per sq. in. by an increase in the carbon content from 0.04 to 0.24 per cent. When the necessary adjustment has been made for the change in carbon content, the maximum load, yield point, and limit of proportionality increase progressively with increasng copper content up to the maximum of 4.0 per cent.

In the series normalised at 800° C., the maximum increase

in tensile properties was obtained by tempering for 2 hr. at 500° C. in both the low- and the medium-carbon series; in the 1.5 per cent. copper steels, the limits of proportionality were increased by 18.0 and 13.0 tons per sq. in., the yield points by 14.5 and 11.5 tons per sq. in., and the maximum loads by 13.2 and 10.2 tons per sq. in., respectively. The notched-bar impact values, however, were poor. Increasing the tempering temperature to 550° C. or the time of tempering at 500° C. to 15 hr. produced a marked improvement in the Izod impact values of the low-carbon series without materially affecting the tensile properties. In the medium-carbon series, however, high impact values were not obtained until the tempering temperature was raised to 600° C., when the tensile properties were not appreciably different from those obtained by normalising alone. The best combination of properties was obtained in steel No. 7, containing 2.0 per cent. of copper, after normalising at 800° C. and tempering for 2 hr. at 550° C.

On oil-hardening from 950° C. and tempering at 500° C. for 3 hours, the maximum loads and yield points increased progressively with an increase in copper content. The Izod impact values tended to fall with an increase in the copper content, but there was no indication of scatter in the low-carbon series, and in the medium-carbon series the values were higher than those obtained after an initial cooling in air from 950° C.

Nickel-Copper Steels

Nickel-Copper Steels. Carbon 0.30 per cent., Nickel 2.2 per cent., Copper 1.2-4.2 per cent. (Steels 14-16).—After an initial normalising treatment at 750° C. followed by reheating at 500° C., a variation in the copper content between 1.0 and 4.0 per cent. had no effect on the mechanical properties of these steels, but after normalising at the higher temperatures air-hardening occurred and the tensile properties increased with an increase in the copper content. The Izod impact figure underwent a marked fall when the copper was increased from 1.0 to 2.0 per cent. and then remained approximately constant.

In the oil-hardened (from 850° C.) and tempered condition (at 500-600° C.) the maximum load, yield point and limit of proportionality increased with an increase in copper content, but the actual values obtained were again affected, as in the chromium steels, by variations in the carbon content.

Nickel-Chromium-Copper Steels. Carbon 0.30 per cent., Nickel 2.0 per cent., Chromium 0.6 and 1.2 per cent., Copper 1.2 and 2.2 per cent. (Steels 17-21).—The steels containing 1.0-2.0 per cent. of copper, 2.0 per cent. of nickel and 0.6-1.4 per cent. of chromium were, with the exception of the 1.0 per cent. copper, 2.0 per cent. nickel, 0.6 per cent. chromium steel No. 17, of the air-hardening type, and reheating at 500° C. after an initial normalising treatment at 750-950° C. produced a combined softening and temper-hardening effect. The mechanical properties were determined after cooling in air from temperatures between 750° and 950° C. followed by reheating for 3 hr. at 500° C. Maximum loads of 55 to 85 tons per sq. in., according to the alloy content and treatment, were obtained, but, with the exception of steels Nos. 17 and 18 initially air-cooled from 750° C., the Izod impact figures were below 20 ft.lb.

On oil-hardening from 850° C. and tempering at 500-600° C., the results show that a greater improvement was obtained by increasing the copper content than by increasing the chromium content in a 2.0 per cent. nickel, 0.6 per cent. chromium, 1.2 per cent. copper steel.

Carbon 0.27 per cent., Nickel 3.5-0.0 per cent., Chromium 0.9 per cent., Copper 0.0-3.4 per cent. (Steels 22-25). Oil-Hardened from 850° C. and Tempered at 500-650° C.—The steels containing copper appeared to temper at a slower rate than the nickel steel, possibly owing to a temper-hardening effect, and after tempering at the lower temperatures (500-550° C.) increasing tensile properties were obtained with an increase in the copper content. At the higher tempering temperatures an increase in the limit of proportionality and yield point with an increase in the copper content was still obtained, but the maximum loads were the same for each steel. In all conditions the nickel chromium steel without copper had the greatest ductility as measured by the elongation and reduction of area.

Mechanical Properties of Forgings

Carbon 0.25-0.32 per cent., Nickel 0.0-2.0 per cent., Chromium 1.4 per cent., Copper 2.0 per cent. (Steels 12, 13 and 21). Normalised at 800° C. and Normalised and Reheated at 500° C. (Forgings ¾-in. dia.).—These steels were intended for an examination of the effect of the size of section on the susceptibility to temper-hardening. Their alloy content was, however, sufficiently high to make them of the air-hardening type, and it was possible to ensure simple temper-hardening only in the larger sections of steels Nos. 12 and 13. A marked improvement in the tensile properties was obtained in all the steel as a result of the reheating treatment at 500° C., but the accompanying Izod impact values were low.

The Effect of 1.0 per cent. of Copper in Carbon, Nickel and Nickel-Chromium Steels.—The results show that the addition of 1.0 per cent. of copper had a very marked effect on the properties of all the steels. It was greatest in the carbon steel in the normalised and reheated condition, and where it produced an increase of 19 tons per sq. in. in the limit of proportionality, 16 tons per sq. in. in the yield point and 12 tons per sq. in. in the maximum load; it was least in the nickel-chromium steel, oil-hardened and tempered. Although the tensile properties of the 1.0 per cent. copper steel at the centre of the forging were appreciably better than those of the 1.5 per cent. nickel steel and approximated to those of the 1.5 per cent. nickel, 0.6 per cent. chromium steel, the Izod impact value of the copper steel was low in comparison. It is possible, however, that this could be improved by an increase in the copper content in conjunction with a higher tempering temperature or by the addition of a small amount of chromium.

Temper Brittleness

The susceptibility to temper-brittleness of the nickel-copper and nickel-chromium-copper steels Nos. 14-25 was measured in the usual way. The results obtained showed that the addition of up to 4 per cent. of copper did not induce temper-brittleness in a 2 per cent. nickel steel, and that the addition of up to 2 per cent. of copper to nickel-chromium steels, or the substitution of copper for nickel in nickel-chromium steels, appeared to have no effect on the susceptibility ratio.

Conclusions

The properties of some nickel, chromium and nickel-chromium steels containing 1-5 per cent. of copper have been examined with special reference to their susceptibility to temper-hardening. The maximum increase in hardness on tempering was usually obtained by reheating at temperatures between 450° and 550° C. after air-cooling from 800° C., the time necessary to reach the maximum hardness being longer the lower the temperature. An increase in carbon content from 0.05 to 0.29 per cent. in steels containing 0.5 per cent. of chromium reduced the increase in hardness obtainable by temper-hardening. In these steels the maximum increase in tensile properties, produced by tempering at 500° after air-cooling from 800° C., was obtained in the presence of 1.5 per cent. of copper. Additional copper up to 4 per cent. produced no further temper-hardening effect. The notched-bar impact figure of the steels temper-hardened at 500° C. was low or irregular, but considerably better values were obtained, with a slight sacrifice of tensile strength, when temper-hardening was carried out at 550° C. The properties of temper-hardened 2.0 per cent. nickel copper steels were slightly inferior to those of the 0.5 per cent. chromium copper steels.

An increase of copper content up to the maximum examined (4 per cent.) produced a marked increase in the limit of proportionality, yield point and maximum load of the

medium-carbon steels containing 0.5 per cent. of chromium normalised at 800° C. The effect was not so pronounced in the low-carbon steels. The susceptibility to air-hardening increased with an increase in copper content and with an increase in normalising temperature, and was observable at lower normalising temperatures in small bars than in large sections. In the absence of air-hardening, the degree of temper-hardening was not affected by variations in normalising temperature between 800° and 1000° C., but some degree of air-hardening greatly assists in securing good properties which result from the simultaneous occurrence of the softening effect of reheating at 500° C. and the hardening effect of copper precipitation.

The steels were also examined in the oil-hardened and tempered condition. Even after quenching in oil from 950° C. the main effect of reheating a steel containing 0.05 per cent of carbon and 0.5 per cent. of chromium was to induce temper-hardening. The properties, as oil-hardened and tempered, of the medium-carbon steels containing chromium or nickel in addition to copper were generally improved by an increase in the copper content above the 1.5 per cent. necessary to give maximum temper-hardening. It appears that part at least of the nickel of such steels may be replaced by a similar weight of copper without detriment to the properties in the oil-hardened and tempered condition. Copper appeared to be without influence in increasing or reducing the susceptibility to temper-brittleness.

The chief advantage of temper-hardening is the simplicity of the treatment, which, however, can only be secured at the sacrifice of some of the properties attainable. The results recorded afford a comparison of the properties of copper-bearing steels obtainable by utilising ordinary quenching and tempering or by employing the temper-hardening process, and show that in sections up to 3¼ in. in diameter the advantage lies with the ordinary method of hardening and tempering. This treatment is essential for obtaining high tensile strength.

Tin in World Industry

A Book of Statistics and Charts

THE 1938 edition of the Statistical Year Book of the International Tin Research and Development Council, compiled by the Council's statistical office at the Hague, shows the progress of tin mining in various parts of the world from the beginning of the industry until the present time. British Malaya, for example, has increased its mine output from about 9,000 tons in 1870 to a record of 77,542 tons in 1937. The Cornish industry, on the other hand, produced over 10,000 tons in 1870, but less than 2,000 tons in 1937.

Among the new features is a chart by means of which tin may be traced from the form in which it leaves the smelter through all the processes to which it is subjected, to the numerous applications in which it is finally used. The book gives statistics for all the industries which consume tin, including tinplate and canning, solder, bearing metals, bronze, collapsible tubes, tinfoil and pewter. It is estimated that the world now uses 65,000 tons of tin annually for tinplate manufacture, 30,000 tons for solder, 12,000 to 15,000 tons for bearing alloys, 10,000 to 12,000 tons for collapsible tubes, 9,000 to 11,000 tons of bronze, 5,000 to 6,000 tons for tinfoil and 2,000 tons for pewter. The quantity of tin used for foil is considerably smaller than the amount so used ten years ago, but in most other industries, particularly in tinplate and canning, the consumption of tin is increasing.

The present edition of the Year Book is illustrated by a large number of graphs, one of which represents the annual average price of tin over a period of nearly 70 years, and clearly shows variations analagous to trade cycles, with a general trend upwards. Those interested in the development of foreign markets will find comprehensive statistics of international trade in tin and all its products, the quantities imported and exported by each country being given in full detail by origin and destination. The book may be obtained from the offices of the International Tin Research and Development Council, 378 Strand, London, W.C.2, price 6s. post free.

According to the June issue of the International Tin Research and Development Council's Bulletin, world apparent consumption of tin has decreased by almost 22 per cent. from 67,500 tons in January-April, 1937, to 52,700 tons in January-April, 1938. World production in the same periods has decreased from 62,300 tons to 57,800 tons.

Consumption statistics for the United Kingdom and the U.S.S.R. are available for five months of this year, and show a decline of 20 per cent. in the United Kingdom to 8,251 tons and an increase of over 44 per cent. in Russia to 9,090 tons, comparison being made in each case with the corresponding period of 1937. The fall in tin consumption this year has been most severe in the United States, where the total for the first four months has decreased by 45 per cent. from 33,050 tons in 1937 to 18,187 tons in 1938. In German there was an increase of 7.3 per cent. to 4,291 tons in January-April, 1938, and in France a decrease of 6.7 per cent. to 3,368 tons. Consumption in Japan increased by 23.7 per cent. to 3,710 tons and in Italy by 34.4 per cent. to 1,697 tons in Canada, Belgium, Holland and Czechoslovakia.

World tinplate production in the first four months of 1938 totalled 910,000 tons, showing a decrease of 38½ per cent. as compared with the total of 1,478,000 tons for the corresponding period of 1937.

Some Recent Metallurgical Patents

Cementation

Impure noble metals, such as silver, are refined by bringing the metal to a finely divided condition or into a condition in which at least one of its dimensions does not exceed one millimetre, heating it, preferably in an oxidising atmosphere, at a raised temperature but below its melting point until the impurities are diffused from the interior to the surface of the metal and then removing the impurities. In the treatment of silver, silver leaf is reduced to flakes, heated in air to about 400° C. and then the oxidised impurities removed by acid that does not attack silver, e.g., warm glacial acetic acid. (See Specification 477,522 of Distillers Co., Ltd., and H. Langwell.)

Iron and Steel Manufacture

In a method of manufacturing steel from iron ores poor in manganese, the ores are first treated in a blast furnace with basic slagging without the addition of manganese for the production of a crude iron poor in manganese, and this product is treated with desulphurising agents, particularly highly basic melts of alkaline earths and alkalies, preferably molten sodium carbonate. The desulphurised product is then worked up into steel in a Thomas converter, basic Martin furnace, or electric furnace. The mixing of the iron and soda may be effected by pouring or stirring. (See Specification 481,878 of Rochlingsche Eisen- Und Stahl-Werke Ges.)

Beryllium Alloy

Beryllium is produced by first forming beryllium sulphide from beryllium chloride and then reducing the beryllium sulphide to the metal. Reduction of the sulphide may be effected by heating it in a stream of hydrogen at 1350° C. or more, or in admixture with powdered aluminium in a current of hydrogen. The beryllium sulphide may be mixed in both of the above reducing operations with a flux such as beryllium fluoride or barium fluoride or a mixture thereof. The beryllium may be distilled, there being present in the condensing chamber, if desired, molten metal such as copper, nickel, aluminium, magnesium, lithium, or the alkaline earth metals, whereby alloys are obtained. (See Specification 482,467 of D. Gardner.)

Iron and Steel

In the production of ingot iron and steel in which molten pig iron, adapted for the Thomas or Bessemer process, is first pre-refined in the converter and then finished in an open-hearth or electric furnace, the pre-refined metal from the converter is poured into a ladle which previously has been partly filled with pig iron, e.g., Bessemer or Thomas pig iron, the charge of pre-refined iron and pig iron, after mixing, being finally poured into the open-hearth or electric furnace. The proportion of pig iron to pre-refined metal to be mixed depends on the desired final carbon content of the iron or steel. (See Specification 478,951 of Neunkircher Eisenwerk Akt.-Ges. Vorm. Geb. Stumm, and J. Haag.)

Distilling Magnesium

The hot vapour issuing from a furnace in which magnesium oxide is reduced with carbon, is first diluted and cooled by means of a stream of cold inert or reducing gas to a temperature below that at which the magnesium vapour begins to condense, the mixture of cooling gases, magnesium, and carbon monoxide being then brought into contact with an inert anhydrous salt or saline mixture, e.g., carnallite, which fuses below the said condensation temperature. The salts may be employed in the solid or liquid form. (See Specification 479,842 of National Processes, Ltd., and S. Robson.)

Removing Gases from Molten Metals

In the treatment of molten metals and alloys for the purpose of removing occluded gases, etc., the melt is subjected to the action of ultra sound waves which vary in frequency or intensity or both at intervals which are short in comparison with the duration of the process and which may be several or many times as long as the period occupied by a single sound vibration. The intensity or the frequency of the vibrations or both may pulsate between values, one of which is at least 10 times that of the other, the time of the high frequency and/or intensity being considerably shorter than that of the low frequency or intensity. The variations in frequency, etc., may be caused to occur in repeated cycles so as to produce the effect of beats or intermittent actions by the co-operation of two generators of closely neighbouring frequencies, the two wave systems produced forming a wave the nodal points of which move about in the melt. The melt may be subjected to the action of vibrations of two or more frequencies, the relative ratios of which are not less than 3 to 1 and one or more of the frequencies may be produced intermittently while the others are produced continuously. The action of the vibrations may be varied during the process and the intensity increased, but not to such a point that cavitation occurs. After the main treatment and to remove the last trace of gas from the melt, cavitation may be induced. The variations may be produced by variations in the generator or when using a continuously and uniformly acting generator by varying the manner in which the transmitter transmits vibrations to the melt. In the same generator the fundamental harmonic and one or more of the higher harmonics may be produced alternatingly or concurrently, and a generator may be caused to act alternately on two or more transmitters, which transmit vibrations in succession to the same or different melts. The treatment of technically pure aluminium is described in detail. (See Specification 479,933 of A. Reis.)

Extracting Nickel

A material suitable for the preparation of nickel carbonyl by direct treatment with carbon monoxide is obtained by reducing a sintered nickel matte by heating it with a solid or liquid carbonaceous material. Suitable carbonaceous materials are coal, coke or anthracite, preferably in the form of dust, or a heavy oil. "Second bottoms" from the Orford "tops and bottoms" process may be passed through a sintering machine, the sulphides being converted into oxides with the evolution of sufficient heat to cause sintering. The sintered matte, preferably in coarse granular form, may be mixed with granular or finely divided solid carbonaceous material 30 per cent. by weight of the matte preferably being used, and the mixture being heated in a rotary kiln to temperatures of 700—1,000°, say 900° C. The sintered and reduced matte may be separated magnetically from excess carbonaceous material and is unaltered on exposure to air at temperatures below 200° C. (See Specification 481,511 of Mond Nickel Co., Ltd., and A. E. Wallis).

Production of Titanium

In a method of obtaining titanium from titanium chloride, a bath consisting of fused alkali halide or alkaline earth halide or both, particularly potassium chloride, is covered with a layer of molten alkali metal and maintained at a high temperature, which may be 700-900° C., and titanium chloride, preferably tetrachloride, is added, for example by introducing it in vapour form into the fused salt bath. The operation may be carried out in an inert atmosphere such as hydrogen. (See Specification 479,014 of Deutsche Gold-und Silber-Scheideanstalt Vorm. Roessler.

Refining Copper

A process for deoxidising copper comprises subjecting the molten copper to the action of a metallic reducing agent, which may be an alkali or alkaline earth metal or magnesium iron, aluminium, or zinc, and a flux consisting of or containing boric anhydride, metaphosphoric acid, or sodium silicate. The reducing agent may be added either before or during the contact of the flux and copper. The flux and copper may be violently intermixed. (See Specification 481,844 of Soc. D'Electro-Chimie, D'Electro-Metallurgie, et des Acieries Electriques D'Ugine.)

Lead-Sodium Alloys

In the production of a lead-sodium alloy in the liquid phase by the reaction of metallic lead and sodium, the apparatus employed is heated by circulating in heat-exchange relationship therewith a body of temperature controlling medium consisting of diphenyl and/or diphenyl oxide, the medium being heated to vaporise it and to give it a temperature sufficient to maintain the reacting materials in a molten state while circulating the vapour through the apparatus and returning the condensed medium for further heating. Preferably, the heat exchange medium is caused to circulate through three zones arranged for the circulation of the medium from the first to the second, and from the second to the third, the medium in the first zone being maintained liquid at a temperature such that it will exert a cooling effect on the reaction vessel, in the third zone being vaporised and at such a temperature that it will maintain the reaction mass liquid, and the medium in the second zone being maintained liquid at a temperature between those of the first and third zones. The vaporised medium from the third zone is initially circulated to the reaction vessel and returned in liquid form to the second zone, and thereafter medium is circulated from the first zone to the reaction vessel to cool it by the removal of exothermic heat, being itself subsequently cooled to the temperature of the first zone and returned thereto. The apparatus described in Specification 481,586 may be employed. The air in all vessels and pipes carrying the molten metals may be displaced by an inert gas such as nitrogen. The alloy is finally cooled and ground. (See Specifiction 481,498 of W. W. Triggs (Du Pont de Nemours & Co., E.I.).

Metallurgical Section

September 3, 1938

Current Topics

Some New Analytical Methods

AN improved method for the determination of arsenic, antimony and tin, developed by J. A. Scherrer, of the Chemistry Division, United States Bureau of Standards, is described in the *Journal of Research* for July. In the new procedure arsenic, antimony and tin are separated from most of the lead in babbitt metal, type metals and solders by digestion in hydrofluoric, nitric and sulphuric acids, and from most of the copper, zinc, lead, etc., in brasses and bronzes by digestion in nitric acid or precipitation by ammonium hydroxide after solution in aquêa regia. The three elements are then converted to sulphates, the arsenic and antimony reduced to the trivalent state, and the three then separated by fractional distillation and determined by titration. The results for antimony and tin as obtained by this method are more accurate than those obtained by so-called direct titration methods. Since the method provides for the isolation of these elements, positive identification of very small amounts of these constituents is facilitated.

Another paper in the same issue of the *Journal of Research* relates to the determination of aluminium in non-ferrous materials. It is stated that since the presence of aluminium, even in very small amounts, is harmful in certain types of bearing metals, solders, and zinc alloys, it is important to have an accurate method for its determination in such materials. Ammomium aurintricarboxylate is used for this purpose, but existing methods are complicated and uncertain. An improved method for the use of this well-known reagent has therefore been developed by J. A. Scherrer and W. D. Mogerman. The new method, which is simple and reliable, consists essentially in subjecting a sulphate solution of the alloy to a preliminary electrolysis in a mercury cathode cell to remove interfering elements and then testing the electrolyte with ammonium aurintricarboxylate. The pink colour so produced is compared with standards prepared in the same way.

An Ingot Iron Investigation

IN spite of the voluminous literature on the heat treatment of such widely-used materials as ingot iron and mild steel, B. Jones, of University College, Cardiff, and N. Gray found—some years ago—that certain peculiar microstructures obtained in these rapidly-cooled materials were difficult to interpret, and in some instances were associated with definite embrittlement. Further investigations reported in a paper read before the Iron and Steel Institute concern two ingot irons and a mild steel which were rapidly cooled from temperatures up to 1,000° C. so that their mechanical properties and microstructures could be examined. The history of the materials from the ingot stage was known, and the complete chemical composition was determined.

It was pointed out that there is a critical range in which marked embrittlement occurs, as shown by low notched-bar impact tests, for both ingot iron and mild steel, on rapid cooling from 875-900° C. and from 700-825° C. respectively. The embrittlement of ingot iron is reduced appreciably by a lower rate of cooling, such as the quenching of bars of increased section. Mild steel gives low impact results after quenching at both rates, but the brittle temperature range is reduced to 730-800° C. by the slower quench, while notch toughness is regained on increasing the temperature to 825-900° C. Martensitic grains are formed in ingot iron and in mild steel by rapid cooling from approximately 835° C. and 730° C. respectively. Maximum embrittlement in mild steel is due to the hard martensite formed at this temperature, which forms a network at the grain boundaries; tempering the steel at 600° C. results in a notch toughness greater than that found in the normalised condition. Martensitic grains in ingot iron do not cause embrittlement when formed from the lower range of temperature in which γ-iron solid solution is produced, such as from 850° C. Heating to a temperature of 875° C., however, results in an appreciable increase in volume of the austenitic areas, and on rapid cooling dilute martensite is formed, chiefly in the neighbourhood of the grain boundaries. This, it is stated, gives rise to a low impact value. The martensitic areas are readily decomposed, especially on quenching from 900° C., and interfere with the character of the grain boundary material, causing marked embrittlement.

Bright Zinc Plating

PROTECTION against rust by the deposition of electro-negative coatings has been adopted by many industries, but the majority of deposited films are dull when the articles emerge from the plating bath and it has been customary to scratchbrush or polish the surface so that a bright finish is obtained. In many cases the cost of this subsequent treatment is too high and the lustre thus obtained is not permanent. In seeking cheaper means for the production of bright deposits, brighteners have been added to the electrolyte, but the general practice has been to dip the articles in a brightening solution after plating. Although this method has been largely used for cadmium, not until recently was it applicable to zinc deposits.

The greatly increased price of cadmium has now revived interest in electro-galvanising, according to a recent paper by R. Speers, read before the Electrodepositors' Technical Society, at Birmingham. The main object is to substitute the cheaper metal, yet to maintain the same degree of protection against rust without any loss in brightness. The change has been most marked in the United States, where large automatic and barrel units have been converted to bright

zinc plating. Bright zinc solutions may be operated over a wide current density range, of which the upper limit is many times higher than that for cadmium plating, and the cost of the electrolyte and its maintenance, due to the wide difference in cost of the two metals, is much lower. The basis of bright plating solutions is zinc sodium cyanide and sodium hydroxide; the difference between various formulæ is chiefly in the nature of the brightening agent and anodes. Mercury has been used as an addition agent, with either pure zinc or zinc-mercury anodes. Deposits from such baths are lustrous, but are not so bright as those from the later non-mercurial solutions. A mercury salt must be added periodically to maintain the brightness of the zinc-mercury deposit. Other formulæ embody patented organic brighteners added in small amounts. The anodes are either of the purest electrolytic zinc or of zinc amalgam. Bright deposits are obtainable over a temperature range of from 20° to 50° C. at cathodic current densities of from 5 to 100 amp. per sq. ft.

To attain the same degree of protection against rust, bright zinc deposits must be at least half as thick again as the corresponding cadmium deposit. For example, where a coating of cadmium 0.0006 inch thick would be applied, 0.0009 inch of bright zinc would be needed to afford equal protection under the same circumstances. The application of the thicker zinc deposit does not imply any greater plating time, since the cathodic current density in a still bright zinc solution is normally twice to three times that of a cadmium solution. Preparation of the iron or steel for bright zinc plating is similar to that for cadmium, but particular care is necessary in rinsing.

Aluminium in Cast Iron

At the present time no reliable method is available for the determination of aluminium in cast iron and ferro-alloys. In view of the rapidly increasing importance of aluminium as an alloy addition to cast iron, and the consequent need for its accurate determination in comparatively large amounts, an investigation of the existing methods has therefore been carried out, by E. Taylor-Austin of the British Cast Iron Research Association (*Analyst*, August, 1938), special attention being paid to the use of 8-hydroxyquinoline, a reagent recently introduced for inorganic analysis. Used under certain conditions, this reagent gives results which are of a high standard of accuracy, both for small (0.05 per cent.) and large (14 per cent.) amounts of aluminium.

This investigation has occupied a period of over one year and every detail of the method has been carefully studied, including the effect of other alloying elements. It has been shown that the method is applicable to all present-day compositions of alloy cast iron, but when chromium is present special precautions must be taken, especially when the proportions of aluminium and chromium present are of the same order or when chromium is in excess. Normally, chromium is present along with aluminium only in irons intended for very particular applications, although it is likely that, in future, chromium will be added as a special addition to irons containing aluminium. Contrary to published literature, under the conditions given, titanium is not precipitated by 8-hydroxyquinoline. Extensive trials have shown that the recommended method described is the most accurate yet devised for the determination of aluminium in cast iron and ferrous materials.

The primary difficulty encountered during the determination of aluminium in ferrous materials is its separation from the large amounts of iron associated with it. There are numerous methods in use at the present time for achieving this object: (1) the Rothé ether separation; (2) sodium hydroxide separation; (3) precipitation of aluminium as phosphate in reduced solution; (4) precipitation of aluminium as hydroxide in reduced solution; (5) removal of iron by precipitation with hydrogen sulphide in ammoniacal tartrate solution; (6) sodium bicarbonate separation; and (7) electrolysis with a mercury cathode. All these separations, with the exception of the last, have been studied in detail, and it appears that none is entirely satisfactory when used singly for amounts of aluminium in excess of 1 per cent., but a combination of the bicarbonate separation and the ammonium sulphide-tartrate separation has proved to be the most satisfactory.

The Rothé ether separation, introduced in 1882, is tedious and exacting. Precipitation as phosphate in reduced solution has often been regarded as unreliable, and the present investigation has shown that this is undoubtedly correct. Precipitation as hydroxide in reduced solution may be accomplished by means of either sodium thiosulphate, or phenylhydrazine. The former yielded only about 75 per cent. of the aluminium present; the latter failed to separate the large amount of iron present. The hydrogen sulphide separation in ammoniacal tartrate solution shows greater promise, but has the disadvantage that samples of more than 1 gram cannot be conveniently handled, owing to the unwieldy bulk of the iron sulphide precipitate. The sodium hydroxide separation is stated to give low results, due to the retention of aluminium by the precipitated ferric hydroxide.

A Portable Source of Heat

It has recently been emphasised by one of the American journals—*Oxy-Acetylene Tips*—that the oxy-acetylene flame has many applications in addition to those involving welding and cutting. Outstanding among these applications are the heat-treating processes, such as flame hardening and flame softening, simple heating operations such as the use of the flame for preheating small metal parts prior to welding, and annealing these parts following welding being done every day in the welding shop. Another application of primary interest in the practice of welding is the use of the flame for bending and straightening operations. Metal parts of delicate nature or even heavy steel plate can be quickly heated at exactly the right spot to permit bending, straightening, or otherwise forming to some desired shape. The many uses of the flame for applications other than the fusion of metals depend not only on the intensity of the flame, but also on its portability and convenience. The blowpipe is easy to manipulate and is available for practically every metal-working plant. With the blowpipe, moreover, it is possible to reach into places which are inaccessible under other heating processes, and a large structure does not have to be dismantled in order to heat the part which is to be bent or straightened. Portability of heat is an important advantage, because the source of heat can be carried to the work instead of carrying the work to the heat.

Bright Nickel Plating in England*

By

N. R. LABAN, B.Sc., A.I.C.

THREE processes are now available in this country, all of which have given satisfactory performance during the last two to three years, under the conditions called for in modern works practice, both as regards manual, semi-automatic and fully automatic application. These are (1) Max Schlötter (B.P. 459,887)—straight nickel. (2) Weisberg and Stoddard (B.P. 464,814)—nickel cobalt. (3) Otto Hinrichsen (B.P. 461,126)—nickel cobalt. The success of the processes has been made possible by the discovery that the presence of certain addition agents to the nickel sulphate type of bath has made it possible to produce lustrous deposits requiring no buffing or colouring after plating.

Bright nickel plating can now be considered an established process, and once the technique is mastered, the operation of the solution will present no greater difficulties than those found with ordinary dull nickel plating solutions, and certainly none comparable with those experienced during the early days of chromium deposition. Much of the information given in this paper has already been published, but for the benefit of those not yet fully acquainted with the subject, some of the descriptions of solution and deposit, and the general advantages claimed for bright nickel deposition are repeated.

Behaviour of an Electrolyte

(1) Produces plate of maximum brilliance at all reasonable current densities and to any commercially specified thickness.

(2) Simple analytical control, preferably well within the scope of skill of a junior works chemist.

(3) Capable of operation at high current densities, to conform with modern demands for high-speed plating.

(4) A wide operative range is essential in order that variations in *p*H, temperature and current densities may not be too critical.

(5) Good throwing power is an essential.

(6) Capable of operation under modern methods of agitation, filtration and heating in order that any existing plant lay-out may not be unduly disturbed. Too much importance cannot be attached to efficient filtration, which avoids the risk of any impurities or foreign material in the solution settling on the work during deposition, thereby seriously marring the final lustre of the deposit and necessitating buffing or colouring, which it is the principal intention of bright nickel plating to avoid.

(7) The solution should be stable after prolonged use, so that the need of analysis and replenishment of the bath is reduced to a minimum.

Ideal Properties of a Deposit

(1) Mirror brightness. This term is meant to imply that degree of lustre usually associated with a highly polished nickel deposit, and must not be confused with the semi-bright deposits obtained by many so-called bright nickel processes, which employ thin deposits on a highly polished base, and usually require some form of final colouring. Moreover, this brightness should persist at all thicknesses of deposit called for by modern specifications.

(2) Good physical properties, including those of adhesion, hardness, ductility and lack of porosity.

(3) Good chemical properties, as, for example, resistance to corrosion.

(4) An adequate protection for the basis metal upon which the deposit has been super-posed.

High current density, permissible with all three processes, enables large outputs to be obtained in the minimum of time, with consequent saving in vat area and floor space, and the lowering of production costs generally. Average current densities of 40-60 amp. per sq. ft. are common to all three processes, and higher figures can be satisfactorily used for special purposes, or when called for by local conditions. Standard specifications of 0.001 inch thickness may thus be comfortably attained in from 30 to 20 minutes or even less and in estimating such thicknesses no allowance is necessary for the normal thickness of deposit removed by nickel finishing, and which in some cases may be as high as 20-25 per cent. of the total thickness of deposit.

Mirror Brightness

Mirror brightness of the deposit has the following advantages :—

(*a*) Elimination of finishing costs as covered by wages, materials, and time normally employed in buffing after nickel plating. These may easily amount to 1¼d. or 1½d. per sq. ft. of surface treated, depending on the size of the article and the thickness of deposit.

(*b*) Saving of labour and time involved in wiring and unwiring between nickel plating and chromium plating operations. It is generally appreciated that the simple handling of an article during its passage through the works costs money, and that the tendency to mechanical damage is extremely high, and the elimination of this risk is a considerable advantage, welcome to the up-to-date manufacturer.

(*c*) Saving in thickness of deposit normally removed in buffing.

(*d*) Elimination of risk of cutting through sharp edges commonly incurred with final buffing.

(*e*) Heavily contoured work can be bright plated in deeper recesses, and the difficulty of removing polishing compositions therefrom is avoided.

(*f*) The elimination of polishing the nickel deposit after plating has made possible the introduction of fully automatic nickel chromium plant with an uninterrupted cycle of plating operations from start to finish.

These advantages in actual money values far outweigh any increased cost of the nickel-cobalt deposit due to higher cost of cobalt. All these advantages apply equally well to the Schlötter process, as any extra cost of the solution is more than offset by the fact that regular additions of its special ingredients are not required after the initial installation, except to make up for the drag-out losses as specified later on when dealing with the question of maintenance.

Operating Conditions

Max Schlötter Bath.

(*a*) *Type of Bath.*—Similar to standard type of nickel plating bath, e.g., nickel sulphate, nickel chloride and boric acid. The brightness of the deposit is controlled by the presence of aromatic sulphonic acids, or their salts, as specified in the aforementioned patent specification.

(*b*) *p*H *Range*—2-5 colorimetric.

(*c*) *Temperature.*—Normal optimum 86-104° F. (30-40° C.). Higher temperatures admissible and recommended for current densities above the range mentioned below.

(*d*) *Current Density.*—30-50 amp. per sq. ft. at temperature range above specified. Lower current densities permissible. Higher current densities are also employed for special purposes, up to 300 amp. per sq. ft. having been successfully used at the lower end of the *p*H range.

(*e*) Good agitation and filtration are essential, but it is recommended that the agitation should not be too exces-

* From a paper read before the Electrodepositors' Technical Society.

sive, and in the case of automatic plant, the movement of the work during its passage through the bath suffices.

(*f*) Anodes should preferably be bagged.

Weisberg and Stoddard Bath.

(*a*) *Type of Bath.*—Standard type of bath, containing nickel sulphate, nickel chloride and boric acid, but highly buffered by means of sodium formate. The brightness of the deposit is controlled by the sodium formate content, formaldehyde content (which acts as a depolariser) and the cobalt content of the solution. These three constituents may be varied up to 25 per cent. or more without any noticeable effect on the brightness of the deposit.

(*b*) Normal *p*H, 3.9.

(*c*) *Temperature.*—Room temperature to 104° F. (40° C.).

(*d*) *Current Density.*—Ordinary working range of 40 to 45 amp. per sq. ft. At this range the cobalt content of the deposit lies between 18 and 22 per cent., but at lower current densities, the percentage of cobalt in the deposit may be greater.

(*e*) Good filtration and agitation essential (compressed air or cathode rod movement are equally effective).

(*f*) Anodes, preferably of nickel-cobalt, should be bagged.

Otto Hinrichsen Bath.

(*a*) *Type of Bath.*—Standard type of bath, embodying nickel sulphate, nickel chloride and boric acid, but highly buffered by means of sodium formate. The brightness of the deposit is controlled by the sodium formate content and the cobalt content of the solution; formaldehyde, which is used in the Weisberg bath, is not employed in this process. Variation of the constituents may be permitted over a wide range without any noticeable effect on the brightness of the deposit.

Metal Additions and Brightening Agents

Max Schlötter Process.

(*a*) No variation in the content of any of the ingredients is required with altering conditions of current density, temperature and *p*H.

(*b*) The bath can be controlled to a considerable extent by maintenance of the gravity, making proportional additions of all salts comprising the electrolyte, to counteract inevitable drag-out losses and dilutions by the introduction of swill water with the work.

(*c*) The usual methods for estimating nickel, chlorides, etc., are employed, and the analysis of the brightening agent, when required, presents no special difficulty. As the brightening agent is not co-deposited, check analyses are only required on very rare occasions.

Weisberg and Stoddard Process.

(*a*) The solution is very easy to control, a periodic analysis for cobalt content, sodium formate and boric acid and formaldehyde being all that is necessary, and in a very short time the intelligent plater can decide by the appearance of the work what additions are necessary.

(*b*) Maintenance of the cobalt content of the bath is assured by the use of nickel-cobalt anodes containing 82 per cent. nickel and 18 per cent. cobalt, with any periodic additions of cobalt sulphate that may seem necessary by analysis to counterbalance that removed by drag-out losses.

(*c*) The consumption of the brightening agents is extremely small, and mostly occurs by drag-out losses, which naturally vary according to the quantity of work done and the contour of the articles plated.

Otto Hinrichsen Process.

(*a*) Simple periodic analysis for nickel sulphate, chloride, cobalt and brightening agent suffice for controlling the bath, and this is well within the scope of any junior chemist.

(*b*) Up to the present it has been the practice to maintain the cobalt content of the bath by the addition of cobalt sulphate in proportion to its electro-chemical equivalent and to the ampere hour consumption. This necessitates keeping a record of the number of amperes passed through the bath during the day, but has the double advantage of providing an easy means of maintaining cobalt additions with only a periodic check analysis by the chemist, and also of giving an indication of the amount of work done during a given period, expressed, of course, by way of current consumption per sq. ft. of area. The nickel content is maintained entirely by the use of nickel anodes.

(*c*) The consumption of the brightening agents is extremely small, and mostly occurs by drag-out losses, which naturally vary according to the quantity of work done and the contour of the articles plated.

No activation process is required by any of the above-mentioned processes during transfer of the work from bright nickel to the chromium tank.

Effect and Removal of Impurities

The principal factor influencing the brightness of the deposit obtained by any of the above processes is the presence of impurities. These may consist of iron, copper, zinc and lead, and their presence is extremely detrimental, because they both diminish the brightness and tend to increase the brittleness of the deposit.

In the case of the Schlötter process, copper and lead are considered the worst offenders, whereas for the nickel-cobalt processes, zinc and lead appear to have given the most trouble, although the presence of iron in any of these processes may lead to embrittlement, and should also be considered a contributory factor to pitting. Usually, the impurities can be removed from the solution by working it upon scrap for some hours at low current densities, such as 2 to 5 amp. per sq. ft.; the deposit will tend to become progressively brighter as this cleansing operation proceeds.

Where impurities are present, their effect can readily be noticed on the plated article. Dark areas in the recesses or where the article makes contact with the jig are the general indication, and a greater tendency to wire-mark in the case of those articles which cannot be jigged or racked is another symptom. If the amount of metallic impurities present is large, then a chemical cleansing of the solution is by far the quicker method of restoring the original brilliance of the deposit. An excellent and easy method is the use of either sodium carbonate, or nickel carbonate, and hydrogen peroxide. For the Schlötter process, the use of nickel carbonate for raising the *p*H of the bath is preferred. The carbonate should be added either in solution or suspension or in plastic form, well agitating the bath whilst making the addition, until the *p*H value has been raised above 5.

Hydrogen peroxide may be employed to oxidise any iron present to the ferric condition, which will then be precipitated as the hydrated oxide. Thorough filtration will remove the precipitate, the excess of hydrogen peroxide being removed by agitating the solution, whilst maintaining it at 140° F. (60° C.). The *p*H can then be adjusted to the normal by means of pure sulphuric acid, and in the case of the Weisberg bath, formaldehyde may then be added to replace that destroyed by the additions of hydrogen peroxide.

General Preparation of Work

All work destined to be bright nickel plated should be given the highest initial finish that economic conditions will permit, in order that full advantage may be taken of the brightening properties of the plating solutions, and subsequent buffing of the deposit at any stage avoided.

Too much importance cannot be attached to providing an adequate cleaning cycle, designed to secure maximum adhesion of the nickel deposit, as it is impracticable to etch the basis metal heavily, thereby destroying the polish, and every effort must be made to preserve as far as possible the initial bright polish. The following is a typical cleaning cycle for

brass: (i) degreasing in trichlorethylene degreaser; (ii) wiping to remove any film or deposit; (iii) treatment in hot alkaline electro cleaner; (iv) rinse in cold running water, preferably agitated; (v) cathodic treatment in cyanide bath; (vi) rinse in cold running water, preferably agitated; (vii) acid dip; (viii) rinse in cold running water, preferably agitated; (ix) bright nickel. In the case of steel it should be:—(i) Treatment in hot caustic soda bath, anodic-cathodic-anodic; (ii) rinse in cold running water, preferably agitated; (iii) anodic sulphuric etch; (iv) rinse in cold running water, preferably agitated; (v) bright nickel.

The trouble due to staining produced by the precipitation of salts from hard water when drying out after leaving cleaners or hot water swills, may sometimes be avoided by the addition of water softening materials, for example, "Calgon," which is a proprietary material, employing amongst its other ingredients, sodium hexameta-phosphate as a softener.

Magnetic Alloys and X-ray Structure

Papers at the British Association Meeting

A SYMPOSIUM on "Magnetic alloys and X-ray structure" was held in conjunction with one of the sectional meetings of the British Association at Cambridge last week.

In his introduction, Professor W. L. Bragg, F.R.S., said that the magnetic properties of materials used for technical purposes have been improved in the most remarkable way in recent years. Better alloys have been discovered with a high permeability for small magnetising forces, or with low hysteresis loss when subjected to magnetic cycles, or with a high coercive force when used for permanent magnets. At the same time, the theory of magnetism has made rapid advances in the hands of the theoretical physicists, and X-ray methods of determining the atomic arrangement in these materals have been improved. The present position is very interesting because it is to be hoped that theory may now begin to play a part in technical achievement.

Dr. E. C. Stoner, F.R.S., dealt with "The general theory of ferromagnetism." He pointed out that in the Weiss treatment, which provides a qualitatively satisfactory formal correlation of many properties of ferromagnetics, it is postulated that the elementary magnets are acted on by a molecular field, equivalent in effect to a magnetic field proportional to the intensity of magnetisation. Such a field will give rise to spontaneous magnetisation below a critical temperature, the Curie temperature, and to paramagnetic behaviour above it. The spontaneous magnetisation normally extends undirectionally over only small regions, domains, and the effect of an external field is to align the directions of magnetisation of the domains.

Fundamental Problems

The elementary magnets in ferromagnetic metals are electron spins, and the molecular field has been satisfactorily interpreted as arising from quantum mechanical interchange interaction. The fundamental problems are those of accounting for the number of effective spins per atom, and the magnitude of the interchange interaction in different materials, and of developing a quantitatively satisfactory treatment of the temperature variation of magnetisation and related effects. Of most importance technologically is the behaviour of ferromagnetics in relatively low fields. The determinative factors for the sequence of reversible and irreversible processes occurring during magnetisation include the natural crystal anistrophy, the magnetostrictive properties of the material, and the distribution and magnitude of internal strains. Although a qualitative interpretation can be given of the main effects, the development of a quantitative treatment for particular materials is as yet at an early stage.

"X-ray structure and ferromagnetism" was the subject of a contribution by Dr. A. J. Bradley. Ferromagnetic alloys contain iron, cobalt or nickel (in the Heusler alloys, manganese). They have crystal structures of a simple type—face-centred cubic, body-centred cubic and (rarely) hexagonal close-packed. Of these types the body-centred cubic is the most favourable for the development of magnetic properties. Some non-magnetic alloys become magnetic when the structure is changed to body-centred cubic from another form. The materials used for permanent magnets (known as "hard" magnetic materials) must be distinguished from "soft" magnetic materials such as are used for transformer cores. The latter have well-formed crystals, the structures of which are in no way abnormal. The former, though essentially of the same types (body-centred cubic and face-centred cubic), never have perfectly formed crystals. Some kind of strain is essential for the development of high coercive force. For example the alloy may be on the point of breaking up into two phases of different compositions. The mechanism of this process may be such as to produce an intermediate metastable state. The alloy remains a permanent magnet so long as this state persists. Careful heat treatment is required to ensure that decomposition proceeds only to the point where the alloy has the best magnetic properties.

Magnetic Saturation

Dealing with "The variation of magnetic saturation intensities with temperature in the iron-nickel-aluminium system," Dr. W. Sucksmith made reference to the necessity for making measurements on a large number of alloys of widely varying physical properties, a new method of measuring the saturation intensity (in fields up to 18,000 gauss) from liquid air temperatures up to the Curie temperature, having been developed. This method requires only about 1/20th gram of the alloy, and is not dependent upon the shape of the specimen. The measurements are equally valid for materials ranging from coarse powders to roughly cut cylinders. Measurements have been made on alloys of which the X-ray structure has been investigated by Bradley and Taylor, the same specimens having been utilised through the collaboration of Dr. Bradley.

Some of the multiphase regions have been investigated, and the results show that the phase boundaries as determined by magnetic methods conform closely to those given by the X-ray data. The different regions usually have characteristic properties, and the effect of heat treatment upon structure changes can be followed quite closely by observation of the magnetic saturation intensity at different temperatures.

Dispersion Hardening Alloys

Mr. D. A. Oliver contributed a paper on "Martensitic permanent magnet steels, and dispersion-hardening alloys." The structures of martensitic permanent magnet steels and dispersion-hardening alloys were illustrated by a selection of photomicrographs. The necessity for X-ray examination is stressed. A summary of the important magnetic properties was given, with special reference to those alloys which are of commercial importance, and the effect of impurities on magnetic properties was discussed. Mention was also made of the improved magnetic properties which can be obtained when these magnetically hard alloys are cooled in a magnetic field.

Iron and Steel Institute

Autumn Meeting to be Held in New York

THE Iron and Steel Institute and the Institute of Metals have accepted a cordial invitation to hold their autumn meetings jointly in the United States and Canada this year. In Canada the visitors will be the guests of the Canadian Institute of Mining and Metallurgy, and in America their hosts will be the American Iron and Steel Institute and the American Institute of Mining and Metallurgical Engineers. Before and after the meeting the members will be able to visit various cities and industrial centres in Canada and the United States.

Papers to be Presented

Two technical sessions will be held in New York, on the afternoon of Monday, October 3, and on the morning of Tuesday, October 4. The session on October 3 will be a joint meeting of both British institutes with the American Iron and Steel Institute and the American Institute of Mining and Metallurgical Engineers, and will take place in the Engineering Societies' Building. The session on October 4 will be a joint meeting of the Iron and Steel Institute with the American Iron and Steel Institute and the Iron and Steel Division of the American Institute of Mining and Metallurgical Engineers; it will take place at the Waldorf Astoria. On the same morning the Institute of Metals will hold a joint meeting with the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers at the Waldorf Astoria.

In addition to the "Third Report of the Steel Castings Research Committee" the following papers will be presented at the meeting: "The Quench-Ageing of Steels," J. H. Andrew and E. M. Trent; "Grain Size and Hardenability in Steels to be Heat-Treated," E. C. Bain; "Modern Rolling-Mill Practice in America (exclusive of Continuous Strip and Sheet Mills)," Quincy Bent; "Precipitation-Hardening in Three Steels containing Vanadium," H. H. Burton and T. F. Russell; "Electric Furnaces in European Steelworks," D. F. Campbell; "The Development of Continuous Strip Mills," D. Eppelsheimer; "American Electric-Furnace Practice," W. M. Farnsworth and E. R. Johnson; "American Soaking-Pit and Reheating Furnace Design and Practice," Frederick M. Gillies and Edwin D. Martin; "Some Comments on the Manufacture of Pig Iron in America," William A. Haven; "Factors Affecting Red-Shortness," F. G. Norris; "The New Steel Plant of the Mysore Iron and Steel Works, Bhadravati, India," D. V. Krishna Rao; "The Development of the Open-Hearth Steel-making Processes in Recent Years in the United States of America," L. F. Reinartz; "The Cold Deformation and Recrystallisation of Metal Crystals with Particular Reference to Alpha-Iron," J. W. Rodgers; "The Conversion of Solid Cementite into Iron and Graphite," H. A. Schwartz; "Specific-Heat/Temperature Curves of Commercially Pure Iron and Certain Plain Carbon Steels," C. Sykes and H. Evans; "Recent Developments in the American Iron and Steel Industry," C. E. Williams; "The Manufacture of Seamless Steel Pipe in the Plants of the National Tube Company," Edwin C. Wright and Stevenson Findlater.

Andrew Carnegie Research Fund

The Council of the Iron and Steel Institute are prepared to make annually a limited number of grants from the Research Fund founded by the late Andrew Carnegie in aid of metallurgical research work. The object of the scheme is not to facilitate ordinary collegiate studies, but to enable students, who have passed through a college curriculum or have been trained in industrial establishments, to conduct researches on problems of practical and scientific importance relating to the metallurgy of iron and steel and allied subjects. Candidates, who must be under 35 years of age, must apply before September 30, on a special form to be obtained from the Secretary of the Institute, 4 Grosvenor Gardens, London, S.W.1.

The value of the grant will depend on the nature of the proposed research work, but the maximum amount granted in any one year will, as a rule, not exceed £100. The grant will be divided into four instalments. Of these, the first will be paid on or about January 1, and the second and third on or about July 1 and October 1, subject to the receipt of adequate progress reports. The final instalment will not be paid until a complete report on the entire research, in a form suitable for publication, has been received; this should be submitted not later than the following May 31 (in exceptional cases, an extension of an additional year may be granted). The Council may, at their discretion, award a further grant in aid of any particular research work, which seems to them sufficiently meritorious to justify further assistance.

The results of the research shall be communicated to the Iron and Steel Institute, which will have the right of priority of publication; subject to the approval of the Council, the papers will be printed in the "Carnegie Scholarship Memoirs." Papers of particular interest may be selected for discussion at meetings of the Iron and Steel Institute.

Steelworks Engineering Prize

The Council of the Iron and Steel Institute have accepted an offer from Captain C. A. Ablett to present a prize of £50 for the best paper on steelworks engineering submitted to the Institute, written by a junior engineer employed in a British iron or steel works, irrespective of whether or not he is a member of the Institute. Competing papers should be marked "Ablett Prize Paper" and sent to the Secretary of the Iron and Steel Institute not later than January 31, 1939. The successful paper will be presented at the annual meeting in May, 1938, and published in the Journal of the Institute.

The Williams prize to the value of £100 is presented annually, subject to the discretion of the Council, to the author of a paper of a practical character adjudged by them to be the best paper of that character presented to the Institute and accepted for publication at the annual or autumn meeting each year, the conditions being that the author of the paper shall be a British subject regularly employed in a British iron or steel works, and that at the time of presenting the paper he shall be employed in such works in a position not superior to that of manager of any one technical department.

Recent Metallurgical Patents

Treating Ores

Chromium ore, particularly chromite, is treated to render it suitable for use in the production of chromium and chromium alloys by subjecting it to a reducing operation and concentrating the product, preferably magnetically. (See Specification 480,767 of A. Hammarberg).

Annealing Alloys

A magnetic alloy which can easily be powdered for use in cores for coils, consists of iron with 7-9 per cent. of silicon and 6-11 per cent. of manganese. The powdered material may be annealed in dry or wet hydrogen for one hour at 1,100° C. and may be insulated by coating the particles with a layer of zinc ammonium phosphate mixed with a binder and subsequently pressed into the required form. (Specification 484,073 of Naamlooze Vennootschap Philips' Gloeilampenfabrieken.

Metallurgical Section

October 1, 1938

Current Topics

Vanadium and Molybdenum

THE Vanadium Corporation of America continues to bring forward information on the improvement of iron castings, so far as general properties are concerned, by the addition of small quantities of vanadium. In a recent book entitled "Vanadium in Cast Iron" it is pointed out that improvements are largely due to a reduction in the size of the graphite flakes, together with an increased uniformity in size and distribution of the graphite, added to which a very homogeneous matrix is produced by the refining effect of the vanadium on the pearlite lamellae. Photomicrographs are given to show the restraining effect which vanadium has on the tendency of cast iron to "open up." It is emphasised that the addition of vanadium is of great advantage for the production of large castings which have to withstand air, steam or water pressure. Repeated heating and cooling tests have shown that the addition of vanadium in a small quantity as 0.1 per cent. is quite sufficient to reduce growth and distortion in cast iron to the extent of 20 per cent.

Simultaneously, the Climax Molybdenum Co. have published a book on "Molybdenum in Steel," in which it is shown that the hardening range of nickel-molybdenum steel is a wide one. The information which has been gathered together in this case has been presented on the loose leaf principle, so that the data may be revised or added to when necessary to keep it up to date as a standard source of reference. Nickel-molybdenum steels are outstanding for their uniformity of response to heat-treatment, relative freedom from distortion during quenching and excellent toughness at a high degree of hardness. Both open hearth and electric furnace steel are produced under conditions of the highest development in furnace practice.

Some Continental Developments

DURING 1937 much German research was directed to the recovery of the valuable minor metals which are present as impurities in non-ferrous metal ores and which hitherto have been wasted, due to ineffectiveness of ore dressing and smelting processes. It is believed that Germany can considerably improve the supply of vanadium, molybdenum, nickel, cobalt, manganese, cadmium, selenium, tellurium, bismuth, and precious metals. A newly developed process enables the recovery of vanadium from the iron ores of Southern Germany. It is stated that large-scale application of this process will enable Germany to produce the whole of its annual vanadium requirements.

Much progress can be made in more effectively recovering metals that occur in very minute amounts in major non-ferrous metal ores. It is pointed out that the recovery of only 200 kilograms of rhenium and gallium from the furnace residue of Mansfield copper shale represents a value of about 2 million marks. It is felt that similar substantial amounts of precious metals, especially gold, can be recovered. The recovery of as much as one gram of gold per metric ton in 1 million metric tons of imported iron ore would yield a by-product gold output of 1 ton, valued at about 2.8 million marks.

German smelter output of zinc reached a new post-war peak in 1937, when 163,210 metric tons was produced, compared with 133,760 tons in 1936 and 50,900 tons in 1933. The greater production was due to new and modernised zinc plants, including the Magdeburg electrolytic smelter controlled by the von Giesche company, which began operations in 1934 with an initial capacity of 40,000 tons, which was later increased to 60,000 tons. The new smelter at Oker (Rammelsberg), controlled by the "Preussag" company, which operates the improved "New Jersey" thermic zinc-producing process, continues to enlarge its plant. In addition to the increased smelter capacity, a greater metal production is favoured by the installation of new processes for the recovery of zinc from low-grade ores and waste minerals, notably iron pyrite deposits at Meggen which contain a high percentage of zinc and pyrite cinder dumps. The potentialities of recovery from this hitherto neglected source are indicated by the fact that the large dumps of pyrite cinders at Sturzelberg, near Neuss, contain about 90,000 metric tons of zinc metal.

Collected Data on Monel Metal

COLLECTED data upon Monel metal, nickel and Inconel has been published by Henry Wiggin & Co., Ltd., as the first of a series of data books giving a summary of properties, applications and available forms, together with working instructions making special reference to sheet metal uses. This book has 88 pages of which 14 are devoted to a tabulation of uses in the process industries, classified alphabetically under the name of the material which is being handled. The book covers all aspects of information which might normally be sought.

Monel, as a nickel alloy, took its name from Mr. Ambrose Monell, who was president of the International Nickel Co. at the time when the alloy was first produced in 1905. This company had for many years been engaged in mining and smelting the nickel ores from the Sudbury district of Ontario, Canada, where one very large belt of ore was found to contain a relatively high percentage of copper in addition to the nickel. As the separation of the two metals was difficult and expensive it was decided to smelt out the metal simultaneously and to examine the commercial merits of the resulting alloy. Thus came into being an alloy which contained approximately two-thirds nickel and one-third copper, except for about 5 per cent. of other metals, for which the name Monel was registered as a trade mark.

Classified uses of Monel, nickel and Inconel, in the book under review are dealt with from different aspects

such as resistance to specific corrosives, uses in the process industries, in the textile industry—dyehouse equipment, bleaching, mercerising, drying and finishing machinery, metal pickling, foodstuffs manufacture, the laundry industry, aircraft and power plant. Emphasis is laid upon the information given for resistance of the nickel-containing alloys towards specific corrosives, and it is stated that due to the many variables it is seldom possible to give definite assurance that any metal will resist a definite set of conditions. Tables showing loss in weight with various strengths of stagnant acids are of little value, because they invariably ignore such variables as degree of aeration, temperature, and degree of agitation. Actual experience in industry is definitely the better guide, and it is upon such experience that the information given in the present data book has been based. With regard to high temperatures it is stated that nickel develops a protective oxide in pure oxidising atmospheres and has given long service up to temperatures between 650° and 700° C. For Monel, on the other hand, the upper useful limit in oxidising atmospheres is 500° C., and the presence of sulphur dioxide somewhat lowers the range of usefulness.

Aluminium Products in Central Europe

AFTER arranging to produce magnesium from domestic raw materials only (potash end-liquor, dolomite, and carnallite), Germany is now endeavouring to develop a local source of alumina for the manufacture of aluminium. Experiments with the use of domestic clay in a small pilot plant have culminated in the construction of a large-scale experimental plant at Lippe. Whereas the small pilot plant had a capacity of only 3 to 5 metric tons of alumina daily, the new works will be capable of producing 8,000 tons annually. It is expected to be completed late this year and by 1941 it is anticipated that expansion will permit it to supply a considerable part of the German alumina requirements.

An elaborate research institute has also been established at the Lauta aluminium works for studying new uses for aluminium and the metal needs of buyers. A new refining plant is under construction at Lauta for producing aluminium of more than 99.99 per cent. purity for exceptional requirements. Germany's production of aluminium is expected to reach the record-breaking level of 175,000 or 180,000 metric tons for 1938. In addition, from 4,000 to 5,000 tons will be produced in German Austria, plans being under way for the expansion of the aluminium-reduction works at Steeg and Lend.

Sintering of Metallic Powders

AT the Kaiser Wilhelm Institut für Metallforschung, in Germany, apparatus and procedure has been developed for the production of dense and compact solid metallic masses from powders and the properties of the resulting products have been closely investigated. According to G. Grube and H. Schlecht (*Zeitsch. für Elektrochemie*, 1938, *44*, 367) the process used involves pressing to the form of a rectangular rod, sintering in a current of highly purified hydrogen, and subsequently working the mass mechanically. Experiments were made on molybdenum powder and on nickel powder produced from carbonyl.

In the case of molybdenum it was found that only with sintering temperatures above 1,000° C. does any increase in density take place; pressure used in the initial compression of the powder proved to have no influence on the temperature at which sintering began. With nickel, increase in density is observable at sintering temperatures from 300° upwards; between 300° and 600° the rise is slower, but above 600° it becomes more rapid indicating onset of crystal growth immediately above that temperature. This is supported by the curves relating electrical conductivity, electrical resistivity and tensile strength with sintering temperature, which indicate that immediately below 600° there is a condition of closer cohesion between the particles. Temperature-resistance curves of specimens heated in hydrogen and in vacuo show that escape of absorbed bases ceases at 300° C. Determinations of tensile strength indicate two ranges of sintering temperature in which tensile strength increases rapidly with rise in temperature of treatment, viz., 300°—500° C. and above 650° C. especially when high pressures are used. The hardness values on nickel samples show that with pressures of over 2,000 kg. per sq. cm. a considerable amount of cold work takes place.

New Plant at English Steelworks

DEVELOPMENTS in the use of coke-oven gas for metallurgical purposes, following investigations at one of the steel plants of Dorman, Long and Co., give confirmation that economy of fuel consumption and extended utilisation of what was once regarded as "waste" heat is the main direction in which higher efficiency in steel manufacture has been achieved. For the past fifteen months three 100-ton furnaces operating solely on coke-oven gas have been in successful use, and a fourth and larger furnace of similar type has now been completed. This new unit forms a later stage in the scheme of modernisation undertaken at the Cleveland works of the company in 1936. There are now four steel furnaces and a 400-ton mixer at this plant operating on straight coke-oven gas from the adjacent coke-oven plant, which was erected two years ago, and is the second largest in Europe. The new furnace is 72 ft. long, and the total length of the bath is 54 ft. Constructed of non-spalling basic bricks, carried in water-cooled skewback castings floating against cushioning springs, this furnace is fired with straight coke-oven gas regulated to a constant pressure of $17\frac{1}{2}$ in. of water, and provision is made for the introduction of a small spray of heated tar so that when desired the gas may be rendered luminous. Gas and air supplies, pressures and temperatures are all measured automatically and graphically recorded.

At their Cleveland works, Dorman, Long and Co. are also erecting a large mechanically-charged blast-furnace for the production of basic iron for steel-making purposes. This furnace is to make the most extensive use possible of automatic operation. Fitted with the latest type of mechanical charging, the operation of which will be entirely automatic, the blast temperatures will also be automatically controlled. The furnace will produce 2,750 tons of basic iron per week, and will be fully equipped with new hot blast stoves, ironstone calcining kilns, and bunkers for raw materials. Coke will be fed by a belt conveyor direct from the new coke-oven plant; iron will be delivered to the steel plant in molten condition in ladles of 45 tons capacity. The gas-cleaning plant is being extended to deal with the gas coming from this furnace, and this gas will be washed and used for steam-raising generally.

Copper Refining*

By
R. D. BURN

THE first step in the production of copper from ore is the concentration of the ore and the important process of this type to-day is flotation concentration. Almost 90 per cent. of world copper to-day is produced from flotation concentrates. The introduction of this type of concentration has had a more profound effect on copper metallurgy than any other improvement in the last fifteen years. It has made low-grade deposits into cheap sources of copper. It has removed the blast furnace and roaster from the copper production flow sheet. It has killed the application of hydro-metallurgical recovery to sulphide ores (*i.e.*, roasting followed by leaching). It has brought about a tendency to segregate the copper-producing centres in the proximity of the mines.

Wet Grinding Process

In a given copper ore, the copper mineral exists as a distinct entity in the form of small particles of chalcopyrite ($CuFeS_2$) or chalcocite (Cu_2S), etc., depending on the type of ore. A photomicrograph shows that these copper mineral particles are surrounded by other minerals which may, or may not, be metal-bearing. By a process of wet grinding in a ball or rod mill, these particles are liberated, and by the addition of reagents in this mill can be selectivity made "unwettable." If now air is blown or sucked through the pulp in a cell in the presence of a frothing agent, these copper mineral particles will collect at the interfaces of the bubbles and concentrate in the froth. Dependent on the particular form of occurrence of the copper, a 2 per cent. ore can yield up to 95 per cent. recovery as a 30 per cent. or even 50 per cent. copper concentrate. The chief cost is grinding; reagents are only added to the extent of 10-20 g. per ton—their reaction zone being a mono-molecular film, a little goes a long way—and for two or three shillings per ton a concentration to the extent mentioned can be brought about.

These concentrate froths are freed from water and charged to large pulverised coal-fired reverberatory furnaces, where the copper is further concentrated into a molten sulphide or matte, which may contain as much as 80 per cent. of copper but on the average runs from 40 to 50 per cent. Where cheap power is available these coal-fired reverberatories tend to be replaced by direct arc furnaces of Heroult type of a size sufficient to require electrodes over 4 ft. in diameter.

The molten matte is transferred to converters and air-blown after the Bessemer principle to blister copper, *i.e.*, an impure form of metallic copper. The chemical constitution of the blister at this stage, which depends very largely on the original ore, determines whether electrolytic refining will be used.

Fire-Refined Copper

If the original ore has been particularly pure and its precious metal contents low, then this blister will also be fairly pure, and may be subjected only to a process of simple fire-refining and cast into the primary shapes—ingots, cakes and billets—for the commercial market. Generally, however, such copper still carries impurities such as nickel, which, while they do not affect its use for mechanical engineering purposes, including alloy production, are sufficient to affect its electrical conductivity, and so preclude its use in the electrical industry for conductivity purposes. In the case of two large producers, these impurities are either so low initially or have been so reduced during blister production that the resulting copper is used for conductivity purposes without being electro-refined.

With the majority of other blisters, the presence of gold, silver and other precious metals, and in one case of elements like bismuth or nickel which cannot be practically removed by fire-refining, makes electro-refining at this stage in production either desirable or necessary. The amount of gold in the blister may even be sufficient to relegate the copper content to the position of a by-product and yet its production as a carrier will be the most economical method of recovering the gold in the ore.

The earliest application of electrodeposition of copper on a commercial scale was that of electrotyping, which seems to have been firmly established by the middle of last century. Copper metallurgists at that time quickly recognised the high purity of such copper. Dick (*Phil. Mag.*, June, 1856) described the use of such copper to study melting and casting conditions; this work actually anticipated the principles as applied to-day for the production of oxygen-free high conductivity coppers. The earliest patents for electro-refining of copper are those of J. B. Elkington, 1865, 1869, taken out in this country; these patents developed later at the works of Elkington, Mason and Co., at Pembery, near Swansea, which later passed into the possession of the Elliott Metal Co., Selly Oak, Birmingham. By 1890 some six electro-refineries were in existence in this country, the largest having an output of 60 tons per week.

An Historic Survey

In 1883 the first electrolytic copper was produced in the United States, by the Balbach Smelting and Refining Co., and by 1890 some nine refineries were in production there, the largest apparently producing 108 tons per week. By 1890 it was realised that electro-refined copper, on account of its high purity and resultant high conductivity, was particularly suitable for electrical work, and as such it commanded a high price. For the past 35 years, electrolytic copper has been the standard copper for use in the electrical industry, and over half of the total world copper produced finds use in that industry.

During the first quarter of the present century the United States rose to the position of *the* world's copper producer, but has recently receded somewhat with the advent of cheap production in Africa, Canada and Chile. In the United Kingdom last year, about half the total copper used was electrolytic, which must be a lower proportion than in any other country. Throughout the world over 80 per cent. of all copper used is electrolytic, and it is safe therefore to regard electrolytic refining generally as an important factor in copper production.

Electro-Refining Systems

The principle of electro-refining is to make the impure blister into the anode in a D.C. circuit and plate out the pure copper on the cathode. The early English systems appear to have been a complete multiple system, *i.e.*, all the anodes and cathodes throughout a circuit were connected in parallel. The cathode at the start of the process was a thin sheet of pure copper known as the starting sheet. Such a system is the more costly from a power consumption point of view.

At least two major United States refineries developed a complete series system. In this process, anodes and cathodes were arranged in the circuit in a continuous series, the back of an anode being the cathode relative to the next anode, and so on. No starting sheets are, of course, necessary and, in practice, the face of the electrode which would act as cathode was coated with a conducting, but parting medium, before insertion in the circuit to facilitate stripping. The older preparations were of a pitch-like nature, but to-day materials like sodium resinate are used. This system is the cheapest for power consumption. For a multitude of reasons this system has found disfavour, and only one refinery is left

*From a paper read before the Electrodepositors' Technical Society.

which uses such a system. This in itself is an indication that the general system now almost universally employed, *i.e.*, the Walker multiple-series system, must be the most suitable for modern practice.

As the name implies, this method is really a combination of the two systems, but in practice it is really a carefully balanced compromise of all conditions, power consumption, type of copper treatable, facilities for working and power distribution, temperature and concentration of electrolyte, acidity, electrode gap, rate of circulation of electrolyte, and so forth. It is, in fact, the result of a series of natural developments of both the older systems combined, in which possible minor advantageous features have been sacrificed to give working facility and latitude.

A Modern Copper Refinery

At the tank house, *i.e.*, electrolytic refinery, of the Ontario Refining Co. situated at Copper Cliff, North Ontario, the first stage in the process can be regarded as that of anode preparation. The usual practice is to charge the blister copper to a large pulverised coal-fired reverberatory furnace; the example illustrated has a hearth 50 by 17 ft. in size, and handles a charge of 350 tons per 24 hours. A recent innovation is the use of a hot metal transfer car. This takes molten copper from the converters and transports 60 tons in the molten condition from the smelter, 1¼ miles away, to the refinery, where it discharges the molten blister direct to the anode furnace.

The blister is subjected to an ordinary fire-refining operation in the furnace, and is cast into anodes by means of two 36 ft. Walker casting wheels, operating simultaneously at the rate of 85 to 100 tons per hour.

The anodes weigh about 530 lb. each, and measure some 36 in. sq. by 1¼ in. thick with cast-on suspension lugs. On being withdrawn from the moulds by air lift, they are cooled in the water tank, being carried therein on the chain conveyor, which moves forward in movements of 3½ in., and so spaces the anodes as used in the tank house. From this bosh, the anodes are withdrawn in batches of 38, *i.e.*, a tank charge, by a special crane hook which maintains this spacing; the batch is set in a special rack car for transport to the tank house, where it is lifted *en bloc* as received and inserted in a tank. The anodes remain in circuit for two cycles of 14 days, during which they yield two crops of cathodes, as described later, and then the residual scrap is returned to the anode furnace (14 per cent. scrap, chiefly in the lugs).

The tank house itself is a building 480 ft. by 340 ft., and contains 1,230 tanks laid out in 32 sections of 38 tanks per section. Each tank is 11 ft. 3 in. long by 3 ft. 6 in. wide and 3 ft. 9½ in. deep, and is made in precast ferro-concrete, lined with antimonial lead. The tanks are all carried on pillars, from which they are electrically insulated. A tank contains 38 anodes, as mentioned previously, charged in bulk by the crane.

Electrolyte Copper Content

The electrolyte contains 3 per cent. copper as sulphate, and carries 13 per cent. free acid, plus colloid additions. The copper content of the electrolyte naturally tends to rise, but is kept to the order stated by the special series of tanks marked liberator tanks. These contain insoluble anodes of antimonial lead and regular cathodes and therefore function to reduce the copper content of the electrolyte. The electrolyte is circulated at a rate equal to 2.5 to 3 gal. per min. to each tank and returns to the heater tanks where it is heated so as to maintain the general temperature in the region of 66° C. (150° F.). From the heater tanks it is pumped to the pressure head tanks and from there it is distributed by gravity to the deposition tanks.

Following the Walker system of electrode arrangements, 38 anodes and 39 cathodes in each tank are arranged in parallel, and the voltage drop across a tank varies with conditions, being usually 180 to 240 m.v. The current density is of the order of 15 amp. per sq. ft. Tanks are arranged in rows of 19 and two such rows make a section. The tanks in a section are in series, and the sections in turn are in series.

The tank house is divided into two equal circuits—each circuit having a voltage of 120 to 150, depending on load, and a current of 11,000 amp. These electrical circuits are arranged to cross the solution circulating systems (of which there are also two) at right-angles. By this means the maximum potential difference between any two points in a circulating system is reduced to one-half of the circuit voltage, and losses and growth due to stray currents are retarded.

Cathode Preparation

The cathode begins life as a starting sheet; in 14 days' deposition this gives a finished cathode weighing about 220 lb. and measuring 3 ft. by 3 ft. by ½ in. thick. The starting sheets for these cathodes are prepared in the special series of tanks, marked stripper tanks. As cathodes, these tanks contain hard rolled mother-blanks, covered originally with a thin smear of oil to facilitate later stripping. Twenty-four hours' deposition gives a sheet about 0.025 in. thick on each side, weighing 10 lb. At the end of this time these are withdrawn, washed, and the thin sheets stripped from the blanks with steel knives. The mother-blanks are grooved along the sides and bottom on each face to enable the sheet to break away with clean edges. These sheets are fitted with loops, 4 in. wide, of the same material which has been cut to strip and a busbar thrust through the loop and the starting sheet is ready for immersion in the tank.

At the end of 14 days' deposition the cathodes are drawn, washed, etc., and are ready for cutting for sales purposes, or remelting to produce primary copper shapes. This casting operation is normally done by charging the cathodes to a large pulverised coal-fired reverberatory furnace, melting and then oxidising the charge to contain 0.9 per cent. oxygen. This is followed by the usual procedure of poling to produce tough-pitch electrolytic copper, which is cast on a wheel of the Clark type, to wirebars, cakes, etc. Temperature is carefully controlled during the whole melting and casting operation.

Impurities and By-product Recovery

The behaviour of impurities in the original blister depends very largely on the particular element concerned. Elements which are "nobler" than copper—particularly silver, gold, platinum group metals—pass into a slime which is formed on the anode and gradually settles and collects in the bottom of the tank in the space below the electrodes. Selenium and tellurium also concentrate in this slime as selenide and telluride of copper, etc. Lead also passes into the slime as the insoluble sulphate. Elements definitely electro-negative to copper pass into the electrolyte, *e.g.*, Ni, Fe, etc., but some may pass to the slimes.

Elements like As, Sb, Bi and Sn behave generally in a manner dependent on the degree to which they are present. Tin passes into solution at the anode, but is deposited later from solution as a basic salt. When As, Sb and Bi are present in small quantity they pass into the slime, if in larger quantity some will pass into the electrolyte. If this concentration in the electrolyte becomes high enough, particularly if acidity falls, they will tend to deposit on the cathode and contaminate the product. Near this limiting concentration this deposition may be as a basic salt.

The possibility of mechanical contamination of the cathode by slime must always be guarded against by the control of circulation and electrode interspace. It is general practice to avoid the presence of As, Sb and Bi in the blister if at all possible. In fact, customs electro-refiners impose a penalty on the presence of these impurities in purchased scrap or anodes.

The accumulation of impurities of the nickel type, which may be accompanied by As and even Bi, is kept below the

danger point by systematic purification of the electrolyte. For this purpose a certain quantity is regularly bled off each day—stripped of its copper by deposition, using insoluble anode (this deposited copper will carry some of the impurities). The solution is then evaporated, nickel and other salts crystallised out and the recovered acid is returned to the tank house—necessary precautions being taken before doing so to ensure that impurities are removed to the desired extent (more reference is made to this later).

At the Ontario Refining Co.'s works the blister used is free from bismuth, but contains appreciable quantities of nickel (0.5 to 1.5 per cent.). This, of course, concentrates chiefly in the electrolyte as sulphate. In this respect acid recovery and electrolyte purification is particularly interesting, although somewhat unique. Removal of the nickel in this process easily ensures that other impurities are kept below desired limits.

Recovery of Precious Metals

The slimes which collect in the tank bottom are removed each 28 days (*i.e.*, each anode cycle) and pumped to the silver refinery. Here they are freed from water and roasted with a regulated sulphuric acid addition to render the copper and nickel soluble as sulphates. The roasted slimes are leached to remove these sulphates and the residue is reduced, refined and cast into anodes of Dorè metal, 17 in. by 9½ in. by ½ in., and weighing about 14 lb. each (99 per cent. silver).

These anodes are charged to the anode basket of Balbach Thum parting cells. There are some 40 of these cells in series, and five Dorè plates are laid in the basket, the bottom of which is a diaphragm. The bottom of the *cell* is a graphite plate and the electrodes are silver "candle-sticks," which make a contact connection, one to the top plate in the basket and the other to the graphite plate on the bottom but at the end of the cell, remote from the basket (current 185 amp., 4 volt per cell). The electrolyte is copper/silver nitrate, and the effect of the current is to dissolve the Dorè plates and redeposit silver crystals round the "candle-stick" cathode outside. These crystals are removed periodically, washed, etc., and melted to 1,000 oz. bars.

Paladium is removed from the foul electrolyte periodically with sodium cyanide. The gold and platinum metals remain as a black slime above the diaphragm in the basket. These slimes are treated with *aqua regia* to dissolve gold and platinum metals, leaving any silver as chloride. The solution is treated with ferrous chloride to precipitate the gold. The precipitated gold is melted and refined electrolytically in Wohlwill cells (anodes 3 by 9 in., cathodes 2½ by 9 in., 175 amp. 2 volt); these cells are 10½ by 10½ by 12 in. deep, heated on electric hotplates, and contain as electrolyte $AuCl_3$, equivalent to 100 g. Au per litre, 100 g. HCl per litre.

The solution after gold removal is cemented with hoop iron to give the platinum group metals as a mixed concentrate which is sent to the Acton refinery of the Mond Nickel Co. for further treatment. The selenium and tellurium in the tank house slimes pass into the flue gases and Dorè slags. These elements are recovered ultimately in the elementary form from these sources and marketed as such.

The Impact Testing of Cast Iron*

By
A. J. NICOL SMITH, B.Sc.

A NEED has long been felt for a simple impact test suitable for use with cast iron. It is generally thought that a test of this type would give useful and important information of the characteristics of the material which could not simply be obtained by other means.

Tests of the weight dropping and the hammer blow types give certain information, but suffer from the impossibility of expressing them quantitatively. The weight dropping test has been used in many forms as a proof test, usually on actual castings, and attempts have been made to give quantitative values to this test by gradually increasing the height of drop until the specimen, which is supported transversely, breaks. The final height of drop is then taken as a measure of the resistance to impact. It is uncertain, however, to what extent the previous blows affect the result of the final blow and the indications of this type of test are uncertain. They are rendered more so by the fact that there are many variations in the details of the test, such as the height of drop, the increase in height per blow, the weight of the tup, etc.

The form of impact test which has been used in the Association's laboratories for many years is the Krupp-Stanton repeated impact test, an English test piece used in a German machine. A cylindrical, 15 mm. diameter specimen with a shallow rounded notch (instead of the square notch used in the original Stanton test for steels) is struck by a cam-actuated falling weight at a rate of 84 blows per minute, being rotated through 180° after each blow. The cam and the weight may both be changed, but as usually used the machine delivers a blow of 0.48 ft. lb. The number of blows required to fracture the test piece is taken as a measure of the impact value. This test gives useful indications, but is hardly suitable for routine work, since the specimen is not simple to prepare and the time taken on the test is very long if, as often happens, the specimen withstands some thousands of blows.

The range of results from poor to good irons is much wider than that given by the transverse or tensile test and may range from, say, 800 blows for a good cylinder iron to over 100,000 for a high quality iron. Results from one iron are apt, however, to be erratic. The reason for this is that with a heavy blow and high drop, this test approximates to the single blow type from which it was felt necessary to get away. At the other extreme it approximates to a fatigue test, small drop and small weight, which takes time and is unsuitable as a routine test. The curve connecting energy input and number of blows is roughly hyperbolic and hence working away from the conditions at each end, the standard condition works at the knee of the curve where slight changes in the metal or surface produce marked differences in result.

Attempts have often been made to determine the resistance to shock of cast irons by correlating this property with the results of some other test. Some success has been obtained on these lines using the area under the load-deflection curve in a transverse test, that is, the work done to fracture the bar. These results can only be obtained when a load-deflection curve is taken, which complicates the transverse test. Formulæ attempting to give a like result from the load and the deflection at full load or some proportion of the full load, are not successful when applied to a variety of irons. An attempt of this sort to deduce the impact resistance from some other property is often regarded with suspicion by metallurgists, particularly those with experience of temper-brittleness in steels.

Tests of the single blow impact type, which are designed to measure the energy used to break the specimen, are not generally applied to cast iron. The common standard impact tests for ductiple materials are the Izod and the Charpy. Each uses a 10 mm. square, notched specimen. In the Charpy test the specimen is broken by a transverse blow, while the Izod test is of the cantilever type, one end of the specimen

* From Bulletin of the British Cast Iron Research Association, Vol. 5, No. 7.

being held in a special vice while the other is struck by the swinging weight. These tests, when applied to cast iron, give very low values, difficult to read with accuracy on the machine and show very little difference from iron to iron. When tests of this type are tried on unnotched cast iron specimens, the difference between different irons is more pronounced, but the results from any one iron are inclined to be random.

The reason for the erratic results given by cast iron when using the standard Charpy and Izod tests is that owing to the comparatively small section, fortuitous variation of graphite flakes can greatly affect the results. In any development of a single blow impact test it seems therefore that: (1) The section should be as large as possible; there must be a limit to this, however, since the specimen should preferably be obtainable from portions of the standard test bars. (2) The specimen should be machined to remove surface irregularities. (3) The test should be on a round bar, since there is no reason to suppose that a square section has any advantages to compensate for the increased difficulty of machining, the liability to chilled edges and the greater difficulty of obtaining a specimen from the standard test bars.

Some Recent Metallurgical Patents

Beryllium Alloys

Beryllium is produced by treating a beryllium ore to obtain beryllium sulphide which is then reduced to the metal. Reduction may be effected by heating the sulphide with a metal, the heat of formation of the sulphide of which is greater than that of beryllium sulphide, e.g., aluminium or calcium, in an atmosphere of a reducing or inert gas or both, and in the substantial absence of moisture, nitrogen, oxygen, and oxygen-containing gases, e.g., in an atmosphere of hydrogen, hydrocarbons, or argon. Reduction may also be effected by heating the beryllium sulphide in a stream of hydrogen at about 1,350° C. or over. The beryllium formed may be distilled, and there may be present in the condensing chamber a molten charge of a metal with which the beryllium is to be alloyed. (See Specification 483,862 of D. Gardner).

Tungsten

Tungsten is produced by first forming tungsten sulphide from a tungsten ore or compound, and thereafter reducing the tungsten sulphide by heating it with a metal, e.g., aluminium, calcium, barium, sodium, or magnesium, the heat of formation of the sulphide of which is greater than that of tungsten sulphide, this operation being effected in an atmosphere of a reducing and/or inert gas and in the substantial absence of moisture, nitrogen, oxygen, or oxygen-containing gas, e.g., in an atmosphere of hydrogen or argon. Pure tungsten salts or other compounds may be employed as initial materials whereby pure tungsten is obtained directly. In examples (1) tungsten trioxide is converted into tungsten sulphide, which is mixed with aluminium chips or powder and heated in a current of hydrogen or argon, the temperature being preferably kept below the melting point (about 1,100° C.) of the aluminium sulphide formed; (2) wolframite is treated for the production of a mixture of tungsten, iron, and manganese sulphides and the mixture is reduced with calcium or aluminium as in example (1). The aluminium or calcium sulphide formed is removed, and the iron and manganese may be separated from the tungsten by dissolving them, e.g., with hydrochloric acid of sp.gr. 1.12 or 1.19. In both of the examples, the quantity of aluminium or calcium used is about 10 per cent. over that theoretically required. Another suitable tungsten-containing ore is scheelite. (See Specification 484,329 of D. Gardner).

Heat-Treating Metals

A molten salt bath for the heat-treatment of metals and alloys at temperatures not exceeding 550° C., e.g., 450-500° C., consists of at least two alkaline earth chlorides and also alkali chlorides, preferably common salt, but is free from potassium chloride or contains that salt only up to 10 per cent. of the total bath. In an example a bath contains 48 per cent. of calcium chloride, 31 of barium chloride and 21 of sodium chloride or 16 of sodium chloride and 5 of lithium chloride. The bath may also contain potassium chloride in an amount not exceeding 10 per cent. of the total bath. The metals referred to are iron, aluminium, magnesium and beryllium and the alloys are iron alloys. (See Specification 484,480 of Deutsche Gold- Und Silber-Scheideanstalt Vorm. Roessler, A. Wille, C. Albrecht, and K. Bonath).

Coating Metals

A plate of copper is coated with cuprous oxide for use as a rectifier by heating the plate to a temperature at which black copper oxide is decomposed, that is above 1,030° C., plunging it in a protective medium liquid at that temperature and allowing it to cool whilst surrounded by such medium. The protective medium may be an alkaline earth metal fluoride, or preferably an equimolecular mixture of barium fluoride and barium chloride which melts at 1,020° C., and it may be located in the oven in which the plate is heated. (See Specification 484,359 of Standard Telephones and Cables, Ltd.).

Distilling Magnesium

Magnesium and other metals capable of being distilled are obtained from their ores or compounds by packing a mixture of the ore, etc., and a solid reducing agent round an electrically conductive primer and heating the whole under reduced pressure by induced currents at a frequency of 600-10,000 cycles per second, preferably about 2,200. The primer is preferably metallic, such as pig iron, ferrochrome, or a wrought iron pipe, and the reducing agents may be carbon, coke, silicon, ferrosilicon, aluminium, calcium, or their alloys, or calcium carbide. (See Specificaton 484,429 of H. A. Blackwell and W. L. Turner).

New Alloy Standards

Ferro-Vanadium and Ni-Cr-Mo Steel

THE Bureau of Analysed Samples, Ltd., announce the following analytically standardised samples which are now ready for issue:—

Ferro-Vanadium No. 205: Vanadium 52.2 per cent., (carbon 0.16, silicon 1.18, sulphur 0.03, phosphorus 0.05), figures in brackets not standardised.

Ni-Cr-Mo Steel "B": Carbon 0.35 per cent., silicon 0.25, sulphur 0.034, phosphorus 0.024, manganese 0.61, nickel 3.05, chromium 0.68, molybdenum 0.34.

Ferro-Vanadium No. 205 is a typical sample of the type of alloy appearing on the British market. It is also useful to chemists for the purpose of adding exact amounts of vanadium to standard steels to bring the vanadium to the required percentage for testing out methods of analysis. Ni-Cr-Mo Steel "B" has a composition similar to one of the typical specifications for this class of material.

As usual, each standard has been analysed by a number of chemists representing independent analysts and chemists representing well-known manufacturers and users. Each purchaser will be provided with a certificate showing the analysis of each chemist and giving an outline of the methods he has used. In particular, modern methods for vanadium, chromium and molybdenum will be of special interest.

The standards are issued in bottles containing 25 g, 50 g, 100 g, at prices estimated to cover the cost of production. The standards may be obtained direct from the Bureau of Analysed Samples, Ltd., 3 Wilson Street, Middlesbrough, or through the usual chemical dealer.

Metallurgical Section

November 5, 1938

Current Topics

Recent Work on Foundry Materials

A CONSIDERABLE amount of useful work is still being done upon refractories, sands, fuels, slags and fluxes of the foundry. The requirements of blast furnace and cupola cokes were discussed before the American Gas Association at a joint committee conference of the production and chemical committees, various tests in use in the United States being examined from a coke producer's viewpoint with particular reference to foundry coke. A modification to the shatter-test machine of the American Society of Testing Materials was described, with a new method of reporting the results from this test. Future possibilities of coke testing were also discussed, and it was suggested that the coke producer should not be satisfied with those tests which report only the averages of many factors, such as reactivity and shatter tests. Definite tests should be prepared in order to study cell size, cell wall thickness, types of carbon and their distribution, the effect of residual volatile matter on reactivity, and also the effect of ash composition on the reactivity of the coke.

With regard to sand for foundry use it has been shown that the relation between dry strength as measured at atmospheric temperatures (after drying at 105° C.) and strength at higher temperatures varies with the type of bond which is used. The usual low temperature test can be used as a control only after its results have been correlated with the behaviour of the sand in the foundry; new control standards must be set up if there is any change in the type of sand or bonding material. N. J. Dunbeck (*Foundry*, 1938, *66*, 32, 80) suggests that in all specifications involving dry strength the temperature at which the strength is to be measured should be given. An examination of the usual methods for the determination of the mechanical grading and strength in compression for moulding sands has been recently reported by T. R. Walker (*Foundry Trade Journal*, 1938, *58*, 455, 483). The various factors which affect the results of these tests were investigated, and it was shown that further standardisation is necessary to enable different workers to obtain concordant results when testing the same sand.

Metals and Alloys of New Interest

A NUMBER of metals and alloys of new interest, especially for the motor car and similar industries, were displayed at the National Metal Exposition which was held at Detroit, Michigan, last month. One of the principal exhibitors was the Electro Metallurgical Co. of New York, who made a special feature of unusual exhibits from the aspect of catching the eye and educating the metal user with reference to some particular property. For example, special etched and fractured samples were exhibited to show the grain-refining action of high nitrogen content in high chromium steel. Another exhibit made a particular point of showing that the corrosion resistance of high chromium metals is fully retained when nitrogen is present. In a further exhibit sprays of water were so arranged that they continually played upon a series of ferrous metal specimens to show the effect of increasing percentages of chromium upon the corrosion resistance. In addition, charts and calculations were presented to indicate the present market prices of the various raw materials which are used in making cast iron, as well as information showing what savings can be effected by the use of briquetted alloys for cupola additions. Specimens of pure manganese, pure chromium and pure silicon were exhibited, together with such interesting alloys as ferro-columbium, silicon-zirconium, calcium-manganese-silicon, ferro-vanadium, and high-nitrogen ferrochrome.

Columbium-bearing stainless steel has now been found to be capable of meeting generally the most exacting requirements, and is of particular interest to the chemical industry where heat exchanges, autoclaves and similar equipment must be highly resistant to corrosion and also to the detrimental effect of heat. The exact kind of stainless steel which is selected will depend very largely on the method of fabrication adopted and upon the severity of the operating conditions, but it has been found generally that small additions of columbium to stainless steel are capable of conferring a remarkable stability of structure even at high temperatures and therefore keep the strength and corrosion resistance at a high value even after months of operation at high temperatures. Autoclaves made of solid columbium-bearing stainless steel have been made by the A. O. Smith Corporation, of Milwaukee, who also use such steel as a lining, automatically welded to a backing of plain carbon steel, in equipment which is to be subjected to high pressures and also high temperatures, as in the case of certain types of heat exchanges and separators.

Surface Cracking in Steel Castings

ROUTINE inspection of large austenitic steel castings have often revealed minute surface cracks, which appear to be more liable to occur in free machining grades rather than in the regular 8/18 grades. P.R. Kosting, in a paper presented before the American Society for Testing Materials, has recently described the examination of typical castings and has given particulars of cooling rates for the steels and of etching methods which have been found most sensitive for revealing the cracks.

The explanation which is advanced to account for cracking is based on the high expansivity and low thermal conductivity of such alloy steels and the low ductility which some of these alloys possess at temperatures around 870° to 980° C., especially if time of deformation is long. As the casting cools in the mould, the skin contracts faster than the mid-section, so that it is in tension. The slower the cooling, the greater will be the loss in ductility, but the lower will be the tensile force due to differential cooling between

the inside and outside of the casting, i.e., a balance of effects exists. If stresses of a sufficiently high order are set up in the proper high-temperature range, brittle fracture will occur, the fracture following the grain boundary. At other temperatures there is sufficient ductility to prevent the building up of high stresses. From this it follows that fine-grained castings will not exhibit such cracks if cooled either quickly or very slowly, and that they may exhibit such cracks if cooled at an intermediate rate which is critical.

A study of heat-treated castings of 6 in. section showed that the benefit of heat-treatment is limited to a surface layer or skin, so thin that it would be destroyed during subsequent processing for removal of oxide, scale, etc. It is considered, therefore, that specifications should limit the cross-section of 18/8 steel castings which are to be heat-treated to secure improved corrosion-resisting properties. In the specification of the American Society for Testing Materials for castings of steel containing nickel 9 per cent. and chromium 20 per cent., the cross-section is limited to 3 in.

Recovery of Manganese from Low-grade Ores

THE successful solution of the electrolytic manganese problem, giving a method for the recovery of high-purity metallic manganese from low-grade ores, is recorded in a progress report which has just been published by the United States Bureau of Mines. The process, which is regarded as commercially feasible, is very different from that described in previous publications. The several steps include roasting the ore in a reducing atmosphere in order to convert the higher oxides of manganese to one and the same oxide, leaching, treatment of leach liquor, filtration and electrolysis. Roasting is done in an externally heated kiln of the rotating type similar to that used in the Caron-Clevenger process, the roasted ore being cooled in a reducing atmosphere. The leaching of the roasted ore is done with spent electrolyte from the electrolytic cells, a liquor which contains about 2.5 to 3 per cent. of sulphuric acid, and the insoluble residue is removed by settling and filtration.

Treatment of the leach liquor for the removal of impurities is a matter of great importance for the success of the process. Iron and arsenic are removed by the addition of manganese dioxide, which is produced as an anode product during the electrolysis, and by agitation by air. The precipitated iron hydroxides, together with the occluded arsenic are removed by filtration and the solution is then treated for cobalt and nickel, both of which have been found to be highly detrimental to the electrolysis of manganese. After filtration the liquor passes to a reservoir which feeds the electrolytic cell. This cell is provided with lead anodes and stainless steel cathodes separated by canvas diaphragms. It is fed continuously, and the spent liquor is run off and filtered in order to recover the manganese dioxide which is formed at the anode and subsequently used in purifying fresh leach liquor as already mentioned, the filtered liquor being returned to the leaching circuit. A current density of 20 amperes per square foot is employed, and it has been found that the energy which is consumed is from 3.2 to 3.7 kilowatt-hours per pound of metal produced. Analysis of the metal has shown that it averages 99.63 per cent. manganese, the principal impurity being sulphur derived from the electrolyte. It is stated that several hundred pounds of this high-purity manganese have already been produced for experimental purposes at the Electro-Metallurgical Laboratory of the Bureau of Mines.

Metallic Calcium

HIGHLY purified calcium metal is now beginning to find new applications as supplies are more readily obtainable. From a metallurgical interest the metal promises to become an important alloying element. Modern methods of production have been fairly recently reviewed in a paper which P. Bastien presented before the Société de Chemie Industrielle, wherein properties and uses of the metal were also discussed. Experiments with sublimed calcium have given a considerable knowledge of the properties of the metal, and, simultaneously, the commercial manufacture of refined calcium has made it possible to study the mechanical properties of the metal more closely, one interesting fact revealed being that calcium is capable of deformation in almost the same way as lead.

Although its lack of corrosion resistance has so far prevented calcium metal from finding any application as a base metal in industrial alloys, the metal has found many uses as a deoxidising or refining agent and as an addition agent for various lead base alloys. The metal proves to be particularly useful as a deoxidiser for copper where a very high electrical conductivity is desired for the copper; it has also been employed for deoxidising and desulphurising nickel and nickel alloys. With or without the simultaneous action of oxidising agents, when added to certain silicon iron alloys, calcium has the effect of making the castings somewhat stronger and of a finer grain. Added to lead as a hardening element, it gives an alloy which has certain advantages over antimonial lead, more particularly from the point of view of stability of mechanical properties reviewed over long periods. This property and also the resistance of lead-calcium alloys to fatigue have already assured a promising market in the cable-sheathing industry as well as in the manufacture of accumulator plates. Metallic calcium has also been used for eliminating bismuth from lead, for lessening the possibility of liquation in the manufacture of leaded bronzes, and for reducing the tendency of molten magnesium to burn when in contact with air.

"Frettage" Corrosion of Metals

A PECULIAR type of corrosion which is commonly associated with closely-fitting metal surfaces, such as shafts, bolts, flanges, etc., and which is particularly noticed in cases where vibration is present, has been under investigation at the National Physical Laboratory. It is characterised by the production of a fine reddish-brown dust between surfaces which are so tightly fitting that no movement appears to be possible. In the case of surfaces which are oiled or greased this corrosion becomes evident in the form of a reddish sludge which slowly oozes out. Accurately-fitting surfaces which have to be taken apart and reassembled are found to develop a bad form of pitting which makes it necessary to renew the parts. This so-called "frettage" corrosion appears to be reduced in effect where certain combinations of soft and hard metals are in use, especially when lubricated, but so far no combination of surfaces has been found to be immune. The phenomenon was exhibited at the National Physical Laboratory on the occasion of the last annual visitors' day.

Investigations in Non-Ferrous Metallurgy

Papers Presented at the Autumn Meeting of the Institute of Metals

THE autumn meeting of the Institute of Metals was arranged to have been held in New York, jointly with the Iron and Steel Institute on October 5, but owing to the September crisis, the American meeting had to be postponed. The autumn meeting, therefore, took place in London, at the Institution of Mechanical Engineers, on October 27.

Two sessions were held for the presentation and discussion of several of the papers that had been planned for reading at the New York meeting, together with other papers. The meeting opened with a statement by the President, Dr. C. H. Desch, F.R.S., of the circumstances which had caused the autumn meeting to be held in London instead of in New York. The following officers were nominated by the Council for 1939-40: President, Dr. C. H. Desch; Vice-Presidents, Lieut.-General Sir J. Ronald Charles, Mr. Kenneth Gray, and Lieut.-Colonel J. H. M. Greenly; members of council, Professor Sir H. C. H. Carpenter, Dr. Maurice Cook, Mr. W. C. Devereux, and Mr. A. J. Murphy.

OXIDATION-RESISTANCE IN COPPER ALLOYS

In a paper on "Oxidation-Resistance in Copper Alloys," L. E. Price, M.A., and G. J. Thomas, B.Sc. (Goldsmiths' Metallurgy Laboratories, Cambridge) said in spite of the large amount of work carried out on heat-resisting alloys, few principles have emerged to guide the choice of alloying elements. In the first part of the paper, some attempt is made to correlate, qualitatively at least, the effect of adding various elements to copper, with the latest theories concerning film formation. Several investigators have studied the oxidation of copper and its alloys, but the experimental conditions have not always been the same, and their measurements may not be comparable with one another.

Wagner (*Z. physikal Chem.*, 1933 [B], *21*, 25; 1936 [B], *32*, 447), Fröhlich (*Z. Metallkunde*, 1936, *28*, 368), and many others agree that the growth of copper oxide films occurs by the diffusion of copper ions outwards through the film. Wagner has shown that (where the electrical conductivity of the oxide film formed on a metal is independent of the oxygen pressure, and the controlling factor is a diffusion process) the constant K of the equation of oxide growth $\frac{d\eta}{dt} = \frac{K}{y}$ should be given by $K = (n_1 + n_2)n_3\kappa E_0/F$ where η is the number of equivalents of oxide produced per cm.^{2} per second, t the time in seconds, y the thickness of the oxide film in cm., F Faraday's number, E_0 the affinity of the metal for oxygen expressed in volts, n_1, n_2, and n_3 the transport numbers of cations, anions, and electrons, respectively, in the film, and κ the specific conductivity of the oxide. The equation has been confirmed for the oxidation of copper at 1,000° C.

Wagner has, as yet, only considered the oxidation and tarnishing of pure metals, but a closer examination of his work suggests that it may be possible to apply the equation to the oxidation of alloys covered with a film of the oxide of one of the alloying elements, as occurs in heat-resisting alloys. The validity of this argument becomes more apparent in the electrochemical derivation of Hoar and Price (*Trans. Faraday Soc.*, 1938, in the Press). The equation should, therefore, apply equally to the oxidation of copper covered with a film of cuprous oxide, or with such an oxide as alumina, provided that in this latter case the conductivity refers to alumina and the transport numbers to the passage of cuprous ions, oxygen ions, and electrons through alumina.

It will be seen, therefore, that provided that $(n_1+n_2)n_3$ does not vary too much from one oxide to another, the rate of oxidation will tend to increase with the conductivity of the oxide film, although an exact proportionality cannot be expected; in other words, high electrical resistance of the oxide goes with high resistance of the alloy to oxidation. There are some exceptions, but in every case an explanation, which is at least reasonable, can be given for the behaviour. Calcium, titanium, and cerium are only very slightly soluble in solid copper, and alloys containing these elements can hardly be expected to develop, over the whole surface, oxide layers free from copper; hence—notwithstanding the high resistance of the pure oxides—the protection conferred by these elements is small. It is doubtful whether, in any case, a film of calcium oxide could confer much protection, since (at least when produced on calcium) the oxide occupies a smaller volume than the metal required to produce it, and is highly porous.

In order to obtain high electrical resistance (and consequently high oxidation-resistance) from alloys containing metals of the early groups, the film formed on the alloy must consist of the pure oxide free from copper or copper ions. Where veins or bridges of copper or copper oxide occur, a diminution in electrical resistance is clearly inevitable. Apparently, a diminution may also occur when foreign cations are in solid solution in the oxide.

The entry of copper ions into a film of the foreign oxide, and their passage outwards through the film to meet the oxygen will be least easy, other things being equal, when the copper ions are much larger than the cations of the metal composing the oxide film.

Certain other factors help to determine whether an alloying constituent is likely to confer protection or not. One is the stability of the oxide; silver oxide decomposes at high temperatures, and it is not surprising that copper containing 4 per cent. silver was found to suffer oxidation at the same rate as pure copper.

Effect of Crystal Structure of the Oxide

It may also be instructive to consider how the crystal structure of the oxide will affect the growth of films. Certain oxides, commonly written as Cu_2O, CoO, FeO, and NiO, are believed actually to contain less metal than these formulæ would seem to indicate. In such cases, vacant spaces occur in the cation lattice, and the deficit of electrons is represented by the fact that cupric as well as cuprous ions are present. Where a cation is adjacent to an empty space, it can very readily move into that space, leaving a void at its previous position into which another cation can move. Electrical considerations suggest that the energy barrier which must be crossed when a cation moves into an adjacent empty space will be small compared with that which has to be overcome in any other type of ionic movement. It is not surprising to find that cobalt, iron, and nickel oxide films fail to reduce materially the oxidation rate of copper.

Oxides such as zinc, cadmium, and stannic oxides, which contain excess cations instead of excess oxygen ions, will not permit this type of transport, although if (as some authorities consider) these oxides have vacant spaces in the anion lattice, oxygen ions might diffuse slowly inwards. In view of the large radius of the oxygen ion, such diffusion is not likely to be very serious. However, it is by no means certain whether these spaces in the anionic lattice really exist.

A consideration of the theory given above, particularly with regard to the alloys of copper with aluminium and beryllium, would seem to indicate that the maximum oxidation-resistance of these alloys is never attained.

Provided that the Wagner theory holds in this case, it appears that the maximum oxidation-resistance of an aluminium-copper alloy has not yet been obtained, e.g., on adding 2½ per cent. aluminium Fröhlich only succeeded in reducing the oxidation velocity by a factor of about 36. The reason for these low values is clearly shown above. It should

be possible, therefore, by carrying out the initial oxidation of aluminium-copper or beryllium-copper alloys under conditions so slightly oxidising that only alumina or beryllia is formed, to obtain a very much greater oxidation-resistance from these alloys than has hitherto been obtained.

This conclusion seemed to be of sufficient practical importance to demand experimental verification.

Improvement of Oxidation-Resistance by Selective Oxidation

Specimens of copper and two aluminium-copper alloys containing 2 and 5 per cent. aluminium, respectively, were machined from extruded rod of $\frac{5}{8}$ in. diameter to $\frac{1}{2}$ in. diameter and lengths of 1 in. The specimens were finished with Hubert 1 F emery, degreased with acetone, and weighed. Selective oxidation was carried out in a 2 in. diameter silica tube furnace with a uniform temperature zone of 12 in. The specimens were supported on platinum, and heated at 800° C. for 15 minutes in a hydrogen atmosphere with 0.1 mm. partial pressure of water vapour obtained by bubbling purified hydrogen through a solution containing 84 per cent. by weight sulphuric acid. After this treatment the alloy containing 5 per cent. aluminium was unaltered in appearance, but the colour of the alloy containing 2 per cent. aluminium had changed to one more nearly approximating to that of pure copper, presumably due to surface impoverishment of the aluminium resulting from the formation of an invisible layer of alumina.

These treated specimens were then heated, together with untreated specimens, in pure oxygen at 800° C. for a period of 4 hrs. and the weight increases observed. The appearance of the selectively oxidised alloy containing 5 per cent. aluminium after this oxidation was most remarkable; the specimens showed no trace of darkening, and, apart from a slight fading of colour, could not be distinguished from a freshly-abraded specimen. The untreated alloy was covered with a black adherent oxide film.

The results on the alloy containing 2 per cent. aluminium were less regular, although in the optimum case the amount of oxidation in a given time was decreased by a factor of 4. In this case, the pretreated alloy was found, after oxidation, to be covered with an invisible film of alumina, small areas of copper oxides occurring at discontinuities in the alumina film. Although the optimum value was not obtained in all the experiments, in every case a selective oxidation resulted in increased resistance to oxidation.

It is possible that the value of the selective oxidation treatment will be more marked for oxidation at lower temperatures, and for the prevention of attack in oxidising atmospheres containing sulphur. It seems to the authors that there is every reason to anticipate that this principle will be applicable to other alloys, e.g., those of iron, nickel, etc., with aluminium, beryllium, etc., where improved oxidation-resistance is desired.

ABSTRACTS OF OTHER PAPERS PRESENTED

Abstracts of other papers presented at the meeting are given below.

"*The Constitution of the Magnesium-Rich Alloys in the Systems Aluminium - Magnesium, Gallium - Magnesium, Indium-Magnesium, and Thallium-Magnesium,*" by W. Hume-Rothery, M.A., D.Sc., F.R.S. (Royal Society Warren Research Fellow, Oxford), and G. V. Raynor, B.A., B.Sc. (Keble College, Oxford).

The equilibrium diagrams for magnesium-rich aluminium-magnesium, gallium-magnesium, indium-magnesium, and thallium-magnesium alloys have been investigated. The liquidus and solidus curves for the magnesium-rich α solid solutions were determined in all four systems and the α solid solubility curve was determined in detail for the alloys with gallium, indium, and thallium. The liquidus curve for the system aluminium-magnesium is distinctly higher than that of previous diagrams, but agrees well with the values given by Haughton and Payne for ternary aluminium-cadmium-magnesium alloys. In the system thallium-magnesium, the solid solubility of thallium in magnesium is greater at high temperatures and smaller at low temperatures than was previously supposed, and the liquidus curve for the more concentrated alloys is higher.

"*Factors Affecting the Liquidus, Solidus, and Solid-Solubility Curves in Some Alloys of Magnesium,*" by W. Hume-Rothery, M.A., D.Sc., F.R.S. (Royal Society Warren Research Fellow, Oxford) and G. V. Raynor, B.A., B.Sc. (Keble College, Oxford).

The factors affecting the solubilities of the B sub-group elements in solid magnesium are discussed with special reference to the metals of Group III B. The fact that solid zinc and cadmium have a smaller tendency to form solid solutions than magnesium, is explained on the basis of the modern electron theory of metals. Of the elements of Group III B, gallium is outside the zone of favourable size-factor for magnesium, and forms a very restricted solid solution, the maximum solid solubility being 3.14 atomic per cent. gallium. Aluminium is on the border-line of favourable size-factor, and its solubility in magnesium, which is very small at low temperatures, increases to 11.5 atomic per cent. at high temperatures, as compared with values of 19.35 atomic per cent. indium and 15.4 atomic per cent. thallium for the two systems where the size-factor is really favourable. Relations existing between the liquidus, solidus, and solid-solubility curves are discussed.

Constitution of Nickel-Aluminium-Copper Alloys

"*Copper-Rich Nickel-Aluminium-Copper Alloys. Part II. The Constitution of the Copper-Nickel-Rich Alloys,*" by W. O. Alexander, B.Sc., Ph.D. (Research Metallurgist, I.C.I. Metals, Ltd., Birmingham).

A series of aluminium-copper-nickel alloys containing from 1 to 35 per cent. aluminium was made, and the phase changes which these ternary alloys undergo on heat-treatment were studied by thermal analysis, and by micrographic and X-ray methods. The phase relations at the solidus and at elevated temperatures are shown to be: (1) primary separation of the compound NiAl containing copper in solid solution; (2) NiAl is isomorphous with the β phase (Cu_3Al) at elevated temperatures, but immiscibility occurs below 750° C.; (3) a eutectic valley runs from the nickel-aluminium to the copper-aluminium binary alloys, the liquid initially separating $\alpha + \theta(Ni_2Al)$, and, below 1,250° C., α + NiAl (isomorphous with β). Thus, at low temperatures two phases of the nickel-aluminium binary system, namely, the compounds NiAl and θ(NiAl), are shown to take some copper into solid solution, and in these forms, i.e., as NiAl solid solution and $\theta(Ni_2Al)$ solid solution, to extend their phase-formation influence right into the copper corner of the ternary diagram to compositions of the order of only 3 per cent. nickel, with 3 and 1 per cent. aluminium, respectively.

"*The Constitution of Aluminium-Zinc Alloys of High Purity: the Nature of the Thermal Change at* 443° C.," by Marie L. V. Gayler, D.Sc. (Scientific Officer, Dept. of Metallurgy, National Physical Laboratory, Teddington), and E. G. Sutherland, B.Sc. (Asst. II., Dept. of Metallurgy, National Physical Laboratory, Teddington).

The liquidus and solidus curves of high-purity aluminium-zinc alloys have been redetermined over a range of composition of 40-100 per cent. zinc by weight. The thermal analyses of alloys stirred continuously show definitely that: (a) the heat-change which occurs on heating takes place over a range of temperature and not at constant temperature; (b) the temperature at which maximum heat-absorption occurs falls with increasing zinc content; and (c) on cooling, a heat-evolution occurs at very nearly constant temperature.

Microscopic analysis shows: (a) no primary separation along the liquidus between the melting point of aluminium and that of the eutectic, other than that of the aluminium solid solution; (b) no evidence of the existence of a two-phase field above 360° C.; and (c) no evidence of a "reaction" compound. The heat-change which occurs over

the range of temperature 440°-470° C., has been shown to be due to a marked change—of about 12 per cent. zinc by weight—in the composition of the primary aluminium phase which takes place during solidification over a very small temperature interval, approximately 12° C. A revised equilibrium diagram is given.

"*The Tarnishing of Silver and Silver Alloys and Its Prevention*," by L. E. Price, M.A., Ph.D. (Goldsmiths' Metallurgy Laboratories, University of Cambridge) and G. J. Thomas, B.Sc., Ph.D. (Goldsmiths' Metallurgy Laboratories, University of Cambridge).

70,000 specimens of pure silver and of 100 of its alloys have been exposed for periods up to one year in 15 different locations, mainly in living-rooms and kitchens. The tarnishing of these specimens has been followed by the observation of the tarnish colours produced, and by an electrometric method.

Although previous investigators have shown that oxide films may retard tarnishing, hitherto it has not been possible to explain why some oxides have a particularly high protective effect against oxidation or tarnishing. A theory has been developed which shows the factors involved in tarnish-resistance. This has explained many previous results, and has indicated that other alloys (e.g. those containing aluminium) which have not previously been found to be tarnish-resistant, become tarnish-resistant when the alloy is heated under such conditions that only the aluminium is oxidised, giving rise to an invisible film of pure alumina. Tarnish-resistant films cannot be formed by heating these alloys in air, owing to the fact that both the silver and its alloy constituents oxidise simultaneously. Optimum results can only be expected with pure films of such oxides as alumina or beryllia, when free from silver oxide.

Two methods have been developed for the formation of such films of pure alumina or beryllia:

(1) Selective oxidation of aluminium or beryllium in silver alloys by heating in hydrogen containing 0.1 mm. partial pressure of water vapour, to give a film of pure alumina or beryllia; and

(2) Superimposing transparent, cathodically-deposited films of these oxides on pure silver and its alloys.

Such oxide films are found to be highly protective against tarnishing.

"*Some Characteristics of Copper-Aluminium Alloys made from Aluminium of very High Purity*," by Marie L. V. Gayler, D.Sc. (Scientific Officer, Dept. of Metallurgy, National Physical Laboratory, Teddington).

It is extremely difficult to obtain a 4 per cent. copper-aluminium alloy made with super-pure French aluminium in such a condition that it will age-harden uniformly to the maximum extent at room temperature. Hot-working, followed by solution heat-treatment at 500° C., results in little or no age-hardening at room temperature. The microscopic examination of such material shows segregated areas of fine particles of $CuAl_2$, which alone would be sufficient to account for non-uniform results. The most satisfactory results were obtained on an alloy of 1 in. diameter section, by cold-forging with a fairly light blow on all faces, down to ½ in. square section, and then on one face down to the required thickness.

It is suggested that the lack of homogeneity in the age-hardening of these alloys is due to the fact that: (a) the alloy is not easily work-hardened, owing to the aluminium matrix being plastically deformed without appreciable work-hardening, probably on account of partial self-annealing during working; and (b) the particles of $CuAl_2$ act in a manner similar to that of the hard particles in a bearing metal and are, consequently, little deformed except under special conditions.

A comparision is made between the characteristics of alloys made with Hoopes' metal and with aluminium of super-purity. High-purity copper-aluminium alloys do not supercool. The macro- and micro-structures of the normally cast alloys are similar to those of commercial alloys which have been supercooled.

Manganese

World Resources of Ore—A New Publication of the Imperial Institute.

THE latest of the mineral publications issued by the Imperial Institute deals with manganese ore and is by Dr. A. W. Groves (Imperial Institute, South Kensington, S.W.7, 164 pp., 3s. 6d. net).

It treats principally of the world resources of this ore, with special emphasis on Empire deposits; but it also contains a large amount of information of a more general character, and deals fully with the mineralogical composition, classification, limits of impurities, uses, marketing, trade and production statistics. The manganese mines, resources, and trade of no less than 55 countries are dealt with in a concise yet comprehensive manner. In this age of steel, manganese is no less a key metal in the manufacture of armaments than it is for many peaceful applications. On the average, about 30 lb. of high-grade manganese ore are consumed for each ton of steel produced, and no acceptable or adequate substitute has yet been discovered, nor is any in prospect. Steel containing about 12 per cent. of manganese has extraordinary resistance to abrasion and is therefore used in many parts subjected to severe mechanical conditions.

Large-scale production of manganese ore is confined to the U.S.S.R., India, the Gold Coast, the Union of South Africa, Brazil, Egypt, and Cuba. Excluding the U.S.S.R., it is noteworthy that the United Kingdom and the other great iron- and steel-producing countries of Europe, as well as the U.S.A. and Canada, have to rely almost entirely upon imports from distant lands for their essential supplies of manganese ore of metallurgical grade. Likewise, with the exception of the U.S.S.R. and the U.S.A., the principal industrial countries of the world are poorly endowed with manganese ore of battery or chemical grade. It follows that the bulk of the world's consumption of manganese ore is ocean-borne. The British Empire is favourably situated with regard to supplies of manganese ore, the reserves in India, the Gold Coast, Union of South Africa, and Malaya reaching a vast total. In 1936, 29 per cent. of the world's production of manganese ore was from Empire countries, but 61 per cent. of the exports came from Empire countries.

Tin Industry

Latest Available Statistics

The October issue of the *Statistical Bulletin*, published by the Hague office of the International Tin Research and Development Council, states that world tin production in August, 1938, amounted to 10,800 tons, making a total of 105,000 tons for the first eight months of this year (as compared with 128,000 tons for the corresponding period of 1937).

World apparent tin consumption in August, 1938, amounted to 11,500 tons, against 10,000 tons in the preceding month and 16,500 tons in August, 1937. Consumption in the first eight months of this year, at 102,300 (129,300) tons, was 21 per cent. below the figure for the first eight months of 1937. Decreases occurred in the U.S.A. and in the United Kingdom, where tin consumption fell by 41 per cent. and 35 per cent. respectively. In the U.S.S.R. and Canada consumption decreased by 10 per cent. In Germany there was an increase of 13 per cent., in Italy of 54 per cent., and in Poland of 56 per cent.

World tinplate production in August, 1938, amounted to 206,000 tons, against 358,000 tons in August, 1937. Tinplate production in the first eight months of 1938 was 1,846,000 tons, showing a decrease of 38 per cent., as compared with the total of 2,986,000 tons in the first months of 1937. The share of the U.S.A. in the total world production fell from 59 per cent. in January-August, 1937, to 48 per cent. in January-August, 1938.

Some Recent Metallurgical Patents

Treating Lead Ores

Finely divided lead ores to be worked up by roasting reaction processes are agglomerated, with or without a binder, and the agglomerates are consolidated by heating them, for example, by the passage therethrough of hot gases which may be combustion gases or the waste gases of the lead hearth. In an example, fine galena, with or without a binder, is mixed with flue dust, lime, and coal and briquetted by means of a press or the like, and the briquettes are heated at from 200° C. to over 400° C. Waste gases from the lead hearth may be passed over or through the briquettes on a conveyor or in a shaft. The circulation of the heating gases may be wholly or partially cyclic. The process is also applicable to flotation ores which may be agglomerated and mixed with fuel or dusted with a coating of fuel. (See Specification 482,224 of Metall-Ges. Akt.-Ges.)

Coating with Metals

Surface layers of the metals of the platinum group, e.g., rhodium, are produced by heating, in a vacuum of at least 10^{-3} mm., e.g., 10^{-4}, of mercury, the metals in the form of structures, e.g., strips, of large surface area per unit volume, and the subliming metal is condensed on work materials arranged in the vicinity of these strips, etc. The work which may be of glass, quartz, ceramic materials, minerals such as asbestos, or inorganic or organic substances is cleaned before treatment, and the metal is clamped at the two narrow edges in copper jaws and heated to a temperature below the melting point by direct electrical heating. The surface area of the strip, etc., may be equal to or smaller or larger than that of the work; if smaller a uniform coating is ensured by moving, e.g., rotating, the strip, etc., or the work. The resulting surface is consolidated by an after treatment such as rubbing with polishing leather or cotton wool impregnated with lubricant. The process may be used to produce weatherproof mirrors, surface layers which are partly permeable to light, condensers, or resistances of high-loading capacity. (See Specification 478,916 of W. C. Heraeus Ges.)

Hard Sintered Alloys

In a process for making sintered hard alloys of the kind in which one or more carbides in finely divided form are mixed with a compound of a bonding metal which is subsequently reduced by heating in a reducing atmosphere, the carbide or mixture of carbides is first prepared in the particle size required in the finished alloy and admixture thereof with an oxide of the bonding metal is effected by prolonged treatment for 50 hours or more in a rotating barrel or similar mixer so that an even smearing of the oxide over the surface of the carbide particles is produced without substantial reduction of their particle size. A mixture of different carbides of different grain size, or a mixture of different samples of the same carbide having varying grain sizes may be employed. The reduction may be effected in an electrically heated tube furnace at 600—1100° C. (See Specification 481,805 of W. H. Hatfield and H. Burden.)

Heat-Treating Alloys

In order to produce fine polyhedral crystals in a casting of an alloy steel containing 5 to 20 per cent. of copper, 10 to 30 per cent. of chromium, and up to 0.3 per cent. of carbon, the casting is rapidly cooled either by casting in chilled moulds or rapidly air-cooling the castings as soon as they can be conveniently removed from the moulds. The castings are then annealed at 750° to 970° C. and may then be quenched or air-cooled and then tempered at 200° to 800° C. The alloy steel may also contain up to 2 per cent. of molybdenum or tungsten and up to 1 per cent. of niobium. According to the Provisional Specification the annealing may be carried out at 700° to 900° C. (See Specification 482,941, of W. P. Digby, and E. T. Digby.)

Desulphurising Iron

Molten iron is desulphurised by being brought into contact with a mixture of 15 to 30 per cent. of soda ash, 30 to 80 per cent. or more of burnt lime, limestone and dolomite, burnt or raw, and 5 to 30 per cent. of fluorspar. The mixture may be used in a highly heated state and may be placed in a container into which the molten iron is poured. The treatment may be carried out in a ladle or in a container between the hot metal mixer and the converter, open-hearth and the electric furnace. In an example the mixture contains 35 per cent. of limestone, 40 per cent. of soda ash, and 25 per cent. of fluorspar. (See Specification 482,820, of J. S. Fraser, and H. A. Brassert and Co., Ltd.)

Heat-Treatment of Alloy Steels

A stainless steel alloy containing 5 to 25 per cent. copper and 10 to 30 per cent. chromium is worked by rolling, forging, drawing, etc., at a temperature between 650 and 1,025° C. preferably between 800 and 900° C. The working is performed continually in one direction so as to preserve the dendritic structure produced in the ingot by slow cooling, the long crystals being all arranged parallel to each other, but cross rolling may be effected at an intermediate stage. The ingot may be worked by hammer cogging from the centre towards the ends after it has been slowly cooled and then reheated in a soaking pit at a temperature of 800 to 900° C., preferably 850° C., and may then be re-heated to a temperature of from 900 to 1,050° C. to allow further working such as forging into a crank shaft or other article, or rolling into strips or plates. The article may then be annealed at a temperature of from 750 to 970° C. a temperature of 910° C. being suitable for a steel containing 15 per cent. chromium and 8-10 per cent. copper, and may subsequently be reheated to 800 to 1,000° C. and tempered by quenching in water or air cooling. Maximum hardness is produced in an alloy containing 10 per cent. copper and 15 per cent. chromium by heating to 500° C. The steel may contain small quantities of other metals, which are used as additions to steel, particularly metals which alloy with copper, and preferably less than 2 per cent. in all, and the carbon content should be less than 0.3 per cent., preferably below 0.12 per cent. (See Specification 479,521 of W. P. Digby and E. T. Digby.)

Silicon Iron

In a process for producing silicon iron, particularly one containing approximately 3 to 5 per cent. of silicon, the iron is first melted alone, then decarbonised by adding one or more readily reacting oxides, then, after removal of any undesired constituents which may have entered the melt, is deoxidised, after which the silicon is added to the molten iron, the whole of the operations being carried out in the aforesaid sequence and under reduced pressure. Iron oxide or manganous oxide may be used for the decarbonisation, the excess of manganese being in the latter case subsequently distilled off. The deoxidation may be performed by a hydrogen atmosphere or by passing hydrogen through the melt; alternatively one or more metals of the second group of the periodic system, especially calcium or beryllium, may be added, the excess being distilled off. One or more of the rare earth metals especially cerium may be employed for deoxidation, instead of, or in addition to hydrogen or calcium, the excess being distilled off. Copper up to 1 per cent. may be added. The silicon may be purified before adding it to the iron, for example by melting it in a quartz crucible under reduced pressure to remove hydrogen. If it contains oxygen and nitrogen, calcium or one of the rare earth metals, such as cerium, may then be added, the excess being distilled off. In order to enable the additions to the molten iron to be made without breaking the partial vacuum, the substances to be added may be contained in a vessel disposed in the melting chamber and having a valve at the bottom which can be operated from outside. (See Specification 484,637 of Heraeus-Vacuumschmelze Akt.-Ges.).

Metallurgical Section

December 3, 1938

Current Topics

Open-Hearth Steel Making

DURING the last ten years the open-hearth process of steel making has been developed to a remarkable degree in the United States, the annual capacity now being above 71 million tons of ingots and castings. The basic open-hearth process, however, has far outstripped the acid open-hearth or Bessemer rivals because of its greater flexibility from the standpoint of pig iron analysis requirements, and also because the basic process can use great varieties of scrap iron and steel. This was revealed in a paper which L. F. Reinartz presented before a recent meeting of the Iron and Steel Institute. It was emphasised that the manufacturer who purchases steel for fabrication into various forms and the metallurgist who is constantly trying to improve the quality of steel products have both challenged the steel plant operator to make higher quality steels at continually decreasing costs. Better performance has followed three distinct lines. First, steel plant managements have spent more time and effort in training the personnel to be cost-minded and quality-minded. Secondly, mechanical improvements have been made by enlarging existing furnaces to the limit, building new modern units, and adding labour-saving devices and other equipment for speeding-up the charging of the furnaces and also the tapping of the heats. The insulation of open-hearth furnaces from top to bottom has considerably aided in reducing fuel costs, and furnace control has been so perfected that both fuel and repair costs have been reduced and an increased hourly tonnage has been simultaneously attained. As a third consideration, the operating metallurgist has demanded greater uniformity in the charge, and has also insisted that more attention be paid to the selection of heavy clean scrap for the production of quality steels.

Extraction and Uses of Indium

R. E. LAWRENCE and L. R. Westbrook (*Industrial and Engineering Chemistry*, 1938, *30*, 611) describe a method for extracting indium from a wet zinc-process residue, and also indicate possible uses for this metal. The indium is concentrated in the waste mud, which is collected and extracted with hot dilute sulphuric acid. The resulting solution, which contains indium and other metals, is treated with metallic zinc in order to precipitate the indium as a sponge which contains also cadmium and a small quantity of lead, nickel, tin and copper. The sponge is filtered off and leached with a carefully controlled amount of hot dilute sulphuric acid to dissolve the cadmium. It is then dissolved in a further quantity of acid, and the solution is filtered to remove the lead sulphate and other insoluble matter. On adding an excess of ammonia the indium is precipitated as hydroxide, which is digested until it becomes granular and is then filtered off, washed and dried and ignited to the trioxide. This indium trioxide still contains some impurities, but metal of a purity of 97 to 98.5 per cent. can be obtained from it by electrolysis. Referring to applications of indium in industry it is pointed out that the most promising outlet seems to be as a constituent of precious metal alloys for dental work and jewellery, where indium is notable for giving an increased resistance against corrosion. Silver alloys containing from 1 to 25 per cent. of indium have been developed for the plating of silverware in order to prevent tarnishing. A dental amalgam containing 95 per cent. of mercury and 5 per cent. of indium has been patented for improving the mechanical properties of the finished filling. The use of indium as a constituent of bearing metals was protected by patent some years ago, and it is believed that this application is again being considered.

Chemical Analysis of Cast Iron

RECENT developments in the chemical analysis of cast iron receive special reference in a recent issue of the bulletin of the British Cast Iron Research Association. It is stated that advances made in the metallurgy of cast iron have necessitated considerable modification to existing methods for chemical examination; elements which were regarded as accidental in their presence until a few years ago, are now being added to cast iron for the purpose of imparting definite physical properties, and on the one hand entirely new methods have become necessary to give accurate values for a particular element (as in the case of aluminium) while on the other hand existing methods for the determination of the more usual constituents of cast iron (total carbon, silicon, manganese, etc.) have also required modification to counteract the interference of the newly added element. It is stated by the author of this particular report, E. Taylor Austin, that the recently introduced method for the estimation of sulphur in cast iron by direct combustion is receiving attention in the laboratories of the British Cast Iron Research Association and it appears likely that this new method will supersede the older gravimetric method, its great advantages being simplicity and speed. The new method is all the more to be welcomed in view of the fact that it has been recognised for a considerable time that other methods for sulphur determination generally yield low results when applied to the analysis of cast iron samples. Reference is also made to the extended usefulness of colorimetric methods of analysis using certain organic reagents; diphenylcarbazide, for example, will now enable chromium to be accurately determined in amounts of the order of 0.001 per cent.

Iron and Steel in Europe

THE consumption of scrap iron and steel in Germany appears to be maintaining the record level which it reached earlier in the year. It is stated that the present monthly scrap consumption is at least 800,000 tons, of which about 100,000 tons is derived from foreign

sources. Shortage of foreign exchange does not permit an increase of purchases abroad, although the international quotations for scrap have been notably low. In consequence the efforts to raise scrap internally continue in spite of statements to the effect that domestic sources are incapable of yielding the quantities which are desired in the interest of Germany's steel supply. The anticipated high level of steel production will possibly be reached without the aid of the Hermann-Goering Werke, the construction of which was originally planned to bring Germany's steel output to the level of 24 million tons yearly in 1940.

Desulphurisation of Pig Iron

IN view of the fact that manganese has largely to be obtained from foreign sources of supply, the desulphurisation of pig iron by means of sodium carbonate is evoking interest in Germany, more especially as the result of numerous metallurgical tests were given in a report which was published in *Sahl und Eisen* in July last. It is doubtful, however, if the process will be used on a very large scale, in view of the difficulty of reducing the cost below Rm. 2 per ton of pig iron. This process of desulphurisation is claimed to take between six and ten minutes, and the most suitable proportion of sodium carbonate relative to the sulphur content of the pig iron is in the ratio of 5 to 1. In order to keep the losses of iron within reasonable limits, carbon is added to the extent of about twenty per cent. of the quantity of sodium carbonate. The process had no adverse effect on the quality of steel which may be produced from the iron, and it is also of note that the process of desulphurisation, applied to pig iron subsequent to tapping, can also be applied to the acid process of smelting low grade iron ore.

An Application of Precipitation Hardening

AN interesting practical application of the ageing of duralumin was afforded recently in the aircraft industry, states the Bulletin of the Ontario Research Foundation. Most sheet metal aircraft parts are assembled with rivets made of this alloy, so far as practice in Canada is concerned, and these rivets are freshly quenched. In this condition it has been found that they are quite amenable to deformation at room temperature, and to avoid the danger of cracked rivets it was a fixed rule that they should be headed within half an hour after quenching. This meant that fresh rivets were delivered to the workers every half hour, at which time unused rivets—aged to the point where hardness interfered with safe riveting—were collected and returned for heat treatment, there being no limit to the number of times that heating and quenching of the rivets could be repeated. Recently, however, some works took advantage of the fact that ageing proceeds more slowly the lower the temperature, and therefore quenched sufficient rivets for a full day's work before commencing to use them. These rivets were stored in dry ice and withdrawn as needed, strict attention being given to the rule that the rivets should be headed within half an hour of their removal from refrigerated storage. The necessity of handling rivets in this way, however, has now been overcome by the development of a new alloy which can be headed quite safely after a completed period of ageing.

Vanadium from Converter Slag

A RECENT issue of *Stahl und Eisen* (No. 28), contains a report concerning tests based on the von Seth process, as carried out by the Rockling'sche Eisen u. Stahlwerke, Voelklingen, for the purpose of extracting vanadium from converter slag. This report, by H. Zieler, contains exhaustive data regarding a series of tests made since 1926, and points to the necessity of making Germany independent of foreign sources for its supply of vanadium ore. In 1937 the consumption of vanadium in Germany was estimated to be between 300 and 400 tons, and it is expected that a still larger quantity will have been consumed during 1938. Up to the present time Germany has imported vanadium ore almost exclusively from its former colony in South-West Africa, where mines are controlled by the Otavi-Minen und Eisenbahn Gesellschaft. It is stated that the German Dogger iron ores contain 0.1 per cent. of vanadium, combined with phosphorus; the French Minette ore, of which the ironworks in Saar district are large consumers, contains 0.07 per cent. of this combination.

Stainless Steel Screens

THE wet screening of ores is a highly corrosive operation as well as an abrasive one, because of the inevitable high degree of oxygenation of the water. Screen cloth made from ordinary or spring steel wire becomes pitted and covered with a film of corrosion products almost immediately, and this causes a rust-blinding of fine mesh screens so that high frictional impedance is offered to the flow of the particles of the ore. The well-known properties of stainless steel, however, enable it to maintain a bright surface and consequently to eliminate rust-blinding, states W. M. Stephen, in technical publication No. 901 of the American Institute of Mining and Metallurgical Engineers. A large tonnage mill grinding hard ore to 65 mesh has been operated in closed circuit, with screens instead of classifiers, quite economically at the Copper Cliff concentrator of the International Nickel Co., of Canada, due to the use of stainless steel screens, which offered no difficulty from the aspect of blinding whereas ordinary carbon steel screens became pitted and blinded with rust within 40 hours of being put into operation.

Colorimetric Estimations in Metallurgy

THERE are now a large number of colorimetric reactions applied to the analysis of metals, and which have been developed principally for use with visual colorimeters. In this connection it has now been made apparent that a photo-electric absorptiometer will give much better results than are possible with the visual colorimeters. A considerable amount of work in this connection has been accomplished at the research laboratory which is maintained by Adam Hilger, Ltd., who are the makers of an absorptiometer which has only recently become known in the metallurgical industry, but is already proving to be an instrument of considerable value. This particular instrument has been used for the determination of copper by the sodium diethyldithio-carbamate method. In the analysis of alloy steels the absorptiometer has been used with great success for the estimation of chromium, titanium, vanadium and manganese, and it is particularly useful in the estimation of iron by thiocyanate.

Modern Developments in the Aluminium Industry*

By
A. N. D. PULLEN, A.I.C.

THE term "modern developments" may be taken to mean the extension of the use of aluminium in fields where it is already fairly well established or the invasion of entirely new fields for which the metal has been rendered suitable by some new process or invention affecting its manufacture. I have selected the second definition as being of more scientific interest since such developments are usually the direct outcome of original research.

All the obvious uses, as well as a number of not so obvious, have already been fully explored and in such cases the final decision usually depends on costs; but there are still many possible markets if only the metal was suitable for the particular purpose or could be made suitable by some treatment process or modification of its properties.

The production of light alloys has, of course, increased the demand for aluminium enormously—practically every week a new proprietary alloy makes its appearance. It is certain that there must be a limit to the possible combinations of the various permissible alloying elements and as that limit is approached so does it become more and more difficult to produce an alloy having any outstanding features different from existing alloys. It may be that this limit has already been reached for mixtures in which aluminium is the preponderating element, but in any case alloy development is included under my first definition of modern developments as it is so largely concerned with the extension of existing uses.

Our primary object is to increase the consumption of the pure metal whether it be for the production of alloys, sheets, tubes or any other purpose, and the best way to do this is undoubtedly to find entirely new outlets.

Corrodibility of Aluminium

For the steel industry certain markets were definitely closed owing to the ease with which the metal corroded. The position was entirely altered by the invention of stainless steel. While aluminium is much superior in this respect to steel it is still not entirely incorrodible, nor will it retain its lustre under atmospheric conditions for any great length of time, whether pure or alloyed, consequently certain limits were set as to its possible uses. One of the aims of the aluminium industry, therefore, is to overcome these difficulties, and to produce an incorrodible metal, although in the case of aluminium this is, strictly speaking, an impossibility.

An incorrodible metal might be defined as a pure metal (or an alloy) which remains unchanged under all natural conditions, and only such metals will be found to occur naturally—gold and platinum, for example. With few exceptions, the stable or naturally occurring state of the common metals is as an oxide or salt, and the tendency is for the " pure " metal to return to one or other of the states under atmospheric influences. As far as I am aware aluminium has never been found occurring free, its commonest companion is silicon, forming complex silicates, and it is obtained from its oxide so that it is rather surprising that it remains as stable as it does.

The explanation lies in its extraordinary affinity for oxygen resulting in the instantaneous formation of a protective surface film. If for any reason the continuity of this film is broken corrosion in one form or another may occur. These breaks may be due to impurities in the metal surface, *e.g.*, weak points due to little or no film forming over the normal alloying constituents or a general weakness in the resistance of the film compared with the corrosive conditions it has to meet. These two difficulties might be overcome by (a) removing the normal impurities, i.e., producing pure metal, and (b) increasing the resisting power of the surface film by artificial means, and research along these lines has resulted in two important developments.

To appreciate such modern developments in the manufacture of aluminium it is desirable to review its past history. Although one of the most commonly occurring metallic elements, it was not isolated until 1827, and was not prepared in any appreciable quantity until about 1880, when the price was of the order of £30 per pound.

First Production of Aluminium at Reasonable Price

In 1890 Hall's process, by which the metal was produced by the electrolysis of aluminium sodium fluorides, was developed in America and aluminium in quantity and at a reasonable price became a commercial possibility. This process, with certain modifications, has remained the standard method for the past 40 years or so. The success of this process, *i.e.*, the purity of the final metal, depends almost entirely on the purification of the bauxite, which is the principal ore used. As mined, this contains appreciable amounts of impurities, *e.g.*, iron, silica, clay, etc., which have to be removed by washing, re-precipitation of alumina, etc. As these purification processes have improved in technique, so has the overall purity of commercial metal risen from about 98 per cent. to the present average standard of about 99.4 per cent., the impurities being practically confined to iron and silicon in more or less equal amounts.

In the early days of the production of commercial aluminium, the average purity was about 98.5 per cent. For the past 20 years or so the average standard of about 99.4 per cent. has been maintained, but at the same time higher purities up to 99.9 per cent. have been regularly produced, but at higher prices. As mentioned earlier, the final purity of the metal depends upon the initial purity of the ore, since there is no cheap method of purification of the metal. It follows, therefore, that fluctuations in the overall purity for one reason or another might be expected. These actually do occur, and by segregation stocks of metal of the higher purities can be obtained.

The metal of to-day which is generally described as pure aluminium can therefore be taken as containing not more than 1 per cent. total impurities, usually less. Strictly speaking, this is an alloy, since it contains small amounts of iron and silicon which affect its properties, chemical, physical and mechanical, and it is as well to remember this when dealing with such properties, since the earlier worker had to use material which was relatively impure. This also applies in some other cases, but in many others pure metal is available, and in consequence more exact measurements have been possible.

Modern Process for Producing High Purity Metal

Fortunately, the position has altered recently and metal is now commercially obtainable which in some cases is almost spectroscopically pure. A refining process was produced in America by Hoope a few years ago by which metal of a purity of about 99.90 per cent. was obtained. The process consisted of the electrolysis at about 1,000° C. of an Al/Cu alloy under a suitable flux, the purified metal rising to the top of the bath. This process suffered from several serious disadvantages, which naturally led to modification. One of these is the result of work by the French company and is the method worked by the British Aluminium Co. under licence.

The refining cell, built of certain refractory materials, consists of three layers. The lower one is formed by a 33 per cent. Cu/Al alloy, which also acts as the anode, above this is a flux consisting of 60 per cent. $BaCl_2$, 23 per cent. AlF_3 and 17 per cent. NaF; the top layer will consist of the refined

* From a paper read before a meeting of the Hull Chemical and Engineering Society on November 15.

metal as it forms, making contact with a graphite cathode. The controlling factor is the composition of the flux, which must be maintained within certain well defined limits, particularly with reference to AlF_3/NaF ratio (1.5), if this falls below 1.3, Ba appears in the refined metal but is readily expelled on readjusting the ratio. Normal commercially pure metal is fed to the lower layer as required, and, while the product can be almost spectroscopically pure, the usual commercial article contains about .005 total impurities, *i.e.*, has a total purity about 99.995 per cent. In England this is known as "S.P.," in France as "Raffinal" and in Germany as "Four Nines."

Properties of the Very High Purity Metal

Work is now being done on this very high purity metal with regard to its chemical, physical and metallurgical properties, and some unusual results have been obtained. Some difficulties have been experienced in the fabrication of sheet owing to contamination of the surface, etc., but where these have been overcome a very resistant product has been obtained. The metal is appreciably softer than normal. Special precautions need to be taken in order to avoid a definite and large crystalline effect appearing on the sheet, the formation of large and uneven grain and subsequent difficulties in working. From the chemical standpoint several statements may need revision. It is still soluble in both acid and alkali, but at a much slower rate, the solution in 10 per cent. NaOH, for instance, may take 2-3 days instead of 2-3 hours. Ammonia appears to be an exception, the rate being much faster. As regards resistance to corrosion, S.P. metal is undoubtedly superior to normal purity, although the results are not always strictly according to theory.

Owing to the relatively limited supply available and the higher price, extensive use of this material cannot be expected just yet. No doubt its use in the design of chemical plant, etc., will increase, but for the present the main output is being absorbed in the manufacture of reflectors for various purposes. The specular reflectivity of aluminium over the visible spectrum is of the order of 88 per cent., but in order to obtain this value very careful preparation of the specimen is necessary and the measurement made at once. Atmospheric tarnishing causes a fairly rapid fall to about 70 per cent., or if the specimen is freely exposed the reflecting surface may be destroyed.

Even with S.P. metal, which is much more resistant, fairly frequent repolishing or cleaning is necessary so that some means had to be found for producing a permanent surface if full advantage was to be taken of the high intrinsic reflectivity possessed by the metal. This difficulty was solved by the invention of a method of electrolytic brightening combined with anodic oxidation. By this means not only was a surface obtained having a very high reflectivity value, but such surface is to all intents and purposes permanent.

Modern Development of Anodic Oxidation

This leads to a consideration of the modern development of anodic oxidation, which depends upon the film forming property of aluminium when made an anode in suitable electrolytes such as sulphuric, chromic or oxalic acids. The main object of such processes is to reinforce or replace the natural oxide skin which exists on the surface of all aluminium with a much thicker film of similar composition and so increase the resistance of the metal to corrosive influences. As a result the use of aluminium has extended into fields where unprotected metal would be unsuitable. This is particularly the case with metal required for architectural or decorative purposes.

One of the properties possessed by the anodic film is the ease with which it absorbs dyestuffs, giving rise to the production of coloured articles of many forms, thousands of which are already on the market. Extremely attractive results can be obtained and this probably explains why so much time seems to have been spent on research on this particular point.

In addition to the dyeing property, the films have also very good corrosion resistance, are hard, and give good electrical insulation, and from the metal manufacturers' point of view it might have been better if development on these lines had received equal attention.

The processes of Bengough using chromic acid, and of Alumilite using sulphuric acid are now too well known to need further description. The former is the Government process and is used extensively for treating aluminium parts for aircraft, etc. The latter originated in America and is the main commercial process, particularly for decorative effects. In all such processes the procedure is much the same in that the article to be treated is attached to the anode bar and current applied under a voltage which may vary from 10-60, depending on the particular electrolyte used. For the purpose for which they were designed these methods are quite satisfactory, but for the treatment of reflectors are of little use, since the films so formed are either opaque or milky.

A fresh method had therefore to be devised which would fulfil the following conditions:—

(a) The high reflectivity of carefully polished metal must not be impaired by the treatment.

(b) The protective film must be colourless and transparent.

(c) The film must withstand reasonable handling and cleaning without scratching.

Electrolytic Polishing

The idea of electrolytic polishing is not entirely new, as Figour and Jacquet devised a method for anodic treatment of copper in a phosphoric acid-ether solution. This, however, was not a commercial process, nor was it applicable to aluminium. An American process for aluminium uses hydrofluoric acid plus boric, chromic or sulphuric acids and has been placed on a commercial basis. In the British Aluminium Co.'s process we use an alkaline electrolyte containing 15 per cent. sodium carbonate plus 5 per cent. sodium phosphate. This is an innovation as all previous electrolytes had been acids. The reflector process resolves itself into two parts, the first the actual electrolytic brightening and the second the application of the protecting film.

As mentioned earlier, aluminium of commerce contains a certain amount of impurities and it is reasonable to suppose that these would play some part in any electrolytic treatment of the metal surface. This proves to be the case and the milky and tinted effects produced by normal anodic processes in an electrolyte capable of giving a clear film are due to these impurities. The reflector electrolyte is therefore designed to remove this defect and it does it by solution. The actual mechanism of the reaction is somewhat obscure, but the fact remains that in order to get good results the original surface film must be removed by solution in the hot alkaline electrolyte and replaced by an extremely thin transparent film formed when the voltage is applied.

The advantage of this method is that instead of building up a film under an existing film of doubtful composition the brightening action can take place directly on to a naked aluminium surface, which at the same time becomes covered with a pure protective layer, and exhibits a brightness at least equal to, but usually superior to, that of the original material.

Electrolyte Giving a Hard Film

The first condition is therefore satisfied. There is now the question of re-inforcement since the film formed during the brightening treatment is too thin and soft to withstand normal wear and tear. The second condition says that the protecting film must be transparent and colourless and this rules out such electrolytes as chromic and oxalic acids as these films are naturally opaque or coloured. After many trials a solution containing 20 per cent. sodium bisulphate was adopted by the British Aluminium Co. for the second part of the treatment. This electrolyte gives a film which is colourless, almost completely transparent, and hard enough

to resist normal wear and tear as well as giving the required protection against likely corrosive influences.

It must be obvious that the invention of such a process opened up several new fields for development, as without it the use of aluminium as reflectors, etc., was not practicable.

For normal reflectors, that is to say, a metal surface designed to reflect light in a certain direction without any high degree of accuracy being required as distinct from a mirror which must conform to certain rigid specification, a reflectivity of not less than 80 per cent. is considered satisfactory. This is readily obtainable, using metal having a purity not below 99.8 per cent. Such metal can be produced in quantity at a reasonable price and is now being used as a general reflector metal

This grade is not entirely satisfactory for mirrors as even with the most careful polishing it is not possible to reduce the degree of diffuse reflection to the desired limits, the surface has slight mottled appearance and the total reflectivity is hardly high enough. By using the super purity grade these defects are removed

NEW STEEL WORKS USING MOLTEN PIG-IRON

Full-scale experiments in the use of the hot-metal process of steel-making have just been carried out in the Clydebridge steelworks of Colvilles, Ltd., at Cambuslang, Glasgow. An open hearth steel furnace at the works was charged with liquid pig-iron brought from the Clyde ironworks, across the River Clyde at Tollcross. The new plant being erected by Colvilles, Ltd., at Tollcross and Cambuslang, at a cost of £2,500,000, will be the first integrated and co-ordinated steel and ironworks in Scotland. It is intended to base steel production on the hot metal process, using molten pig-iron as it runs from the blast-furnace, without allowing it to solidify before charging it into the steel furnaces. The full scheme is far from complete, and it may be a year before it is ready. A 600-ton metal mixer is in course of construction at the end of the present melting shop in the Clydebridge steelworks. This will store liquid pig-iron, and will provide a uniform quality of material. The pig-iron will be brought to the steelworks from the Tollcross ironworks in 60-ton transport ladles over a special bridge which has already been built across the Clyde.

CAUSE OF "SWEATING" OF TINPLATE

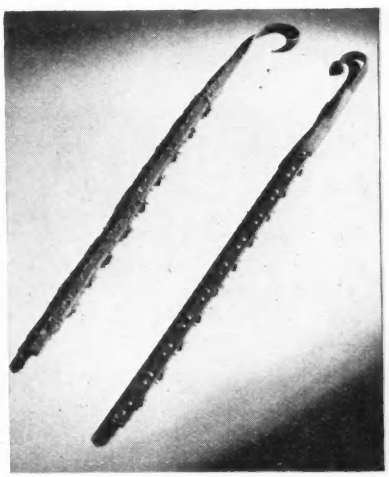
Tinplates stored in a damp place sometimes become covered with droplets of liquid, a defect known in some works as "sweating." Paul Rocquet, in Publication No. 80 of the International Tin Research and Development Council, shows that inclusions of zinc chloride trapped under the tin coating are responsible.

He states that every pit or fissure, which may be produced in the course of the pickling that precedes the tinning of the steel, may retain by capillarity a small quantity of flux which becomes an inclusion. As minute crevices are inevitable whatever the type of steel used these flux inclusions are always present under hot dipped tin coatings. In the case of steels containing silicon a type of intercrystalline corrosion may increase the number of inclusions. However, by suitably regulating the pickling, this corrosion can be completely eliminated and the amount of flux inclusions considerably lessened.

Copies of the above publication may be obtained free of charge on application to the Secretary, International Tin Research and Development Council, Manfield House, 378 Strand, London, W.C.2.

ELECTRO-PLATING WITHOUT WASTE

It is claimed that a remarkable saving in nickel and similar metals employed in the electro-plating industry can be effected by the simple expedient of covering the supporting rods with sheaths of bakelite laminated material. In electro-deposition the articles to be plated are made part of the electrical circuit by suspension in the plating solution on metal hooks or supporting rods. Unfortunately, by this means the plating process is not confined to the articles on which a deposit is required. A very heavy coating will, in the course of time, be deposited on the rods themselves, so resulting in a



considerable waste of valuable plating metal. Recent experience has shown that sheathing the hooks with laminated material manufactured by Bakelite, Ltd., largely prevents waste of this nature, due, of course, to the material's electrical insulating properties. In the accompanying illustration, both plating hooks have seen lengthy service and the unprotected metal is plated in certain sections to a thickness of nearly ⅛ in., while, as will be noted, the sheathed hook is relatively unaffected. The cost of covering the hooks in this manner is said to be very low, while the ultimate saving in plating metal is considerable.

Some Recent Metallurgical Patents

Alloys

An aluminium alloy contains 3.5-5.5 per cent. of copper, 0.3-1.4 per cent. of magnesium, 0.3-1.2 per cent. of manganese, 0.3-1 per cent. of silicon, and less than 0.5 per cent. of iron. A coating therefore comprises an aluminium alloy containing 0.3-2 per cent. of magnesium, 0.3-1.5 per cent. of silicon, 0-1.5 per cent. of manganese, and less than 0.5 per cent. of iron. A soldering medium used in the plating process comprises an aluminium alloy containing, besides commercial impurities, 1-10 per cent. of cadmium or tin to lower the melting point. (See Specification 485,956 of Aluminiumwalzwerk Wutoschingen Ges.).

Case-Hardening

A salt bath for case-hardening iron and steel comprises 10-50, preferably 15-45 per cent. of sodium cyanide, 15-60, preferably 25-30, of barium carbonate, 4-15 of activated carbon of low combustibility, and from 15-70 of a salt molten at the case-hardening temperature, such as sodium or potassium chloride or a mixture of these salts, the amount of this salt being such as to render the bath molten. Barium oxide may be used instead of barium carbonate and the bath may also contain 15-30 per cent. of barium chloride. The activated carbon may be that prepared by the processes described in German Specifications 453,972, 466,358, and 488,669. (See Specification 486,232 of Houghton and Co., E.F.).

Alloys

Electrically-conductive wires or bars for traversing glass or ceramic material, for example in vacuum vessels, sparking plugs, etc., are made by sintering an intimate mixture of pure powders of iron, nickel, and cobalt at about 1,300° to 1,400° C., the products containing less than 0.3 per cent. of impurities such as silicon, manganese, and carbon. The drums or mills in which the powders are mixed, or the walls thereof, may be made of one or more of the metals iron, nickel, and cobalt. Examples of the alloys made consist of (1) 70 per cent. of iron, 20 per cent. of nickel, and 10 per cent. of cobalt; (2) 50 per cent. of iron, 30 per cent. of nickel, and 20 per cent. of cobalt. (See Specification 482,586, of Naamlooze Vennootschap Molybdenum Co.)

Aluminium Alloys

An aluminium alloy contains 0.3 to 16 per cent. of zinc, 0.1 to 1 per cent. of chromium, 0.1 to 1 per cent. of manganese, and 0.05 to 1 per cent. of titanium, with or without 0.1 to 5 per cent. of magnesium, and is made by adding to molten aluminium a chromium-aluminium alloy, a manganese-titanium-aluminium alloy, and zinc. The molten product may be treated for grain refinement by introducing chlorine and the vapour of a boron or vanadium halide or oxychloride, for example boron trichloride, or vanadium tetrachloride, or both. The boron or vanadium content of the alloy may be 0.1 to 0.2 per cent. (See Specification 482,887, of P. Oakley, and D. R. Tullis.)

Heat-Treating Aluminium Alloys

The resistance to corrosion of work-pieces of aluminium alloys containing 3 to 16 per cent. of magnesium is increased by subjecting the work-pieces to a heat-treatment in a solid state, in contact with an oxidising medium at temperatures and for time sufficient to cause, by intracrystalline diffusion, the formation of a superficial zone at least 0.1 mm. thick, having an average magnesium content not exceeding 2 per cent. The heat-treatment may be carried out in an atmosphere of oxidising gas for at least three days, *e.g.*, in air at a temperature of 440° C. or in a fused saline bath, which may consist wholly or mainly of alkaline dichromates or nitrates for at least eight hours. The temperature of the saline bath may be 460° C. If the alloy contains a heterogeneous component rich in magnesium, the alloy is first homogenised, e.g., at 460° C, before being subjected to the heat-treatment. (See Specification 483,244, of W. H. A. Thiemann (I. G. Farbenindustrie Akt.-Ges.)

Coating Metals

After the treatment of iron, steel, or zinc surfaces with solutions containing chromic acid, chromates, or dichromates, with or without mineral acids or mineral acid salts, to form protective coatings, the surfaces are rinsed with solutions containing chromic acid, oxalic acid, phosphoric acid, chromium salts, iron salts, or aluminium salts, or mixtures of these substances. The rinsing solution is less acidic than the coating solution and the rinsing may be done as soon as a superficial coating has been formed, after the reaction of the coating solution is complete, or after the original coating has been formed, dried, and baked. The rinsing is preferably carried out at a temperature of about 200° F., and it may be followed by a hot or cold water rinse. The rinsing increases the resistance to corrosion and prevents the formation of blisters when siccative coatings such as paint, enamel, or lacquer are subsequently applied. A preferred rinsing solution contains 4 grams of chromic acid per gallon of water: solutions of ferric, chromic or aluminium nitrate are also specified. A coating solution containing 35 grams of chromic acid and 65 grams of sodium chloride in 3 litres of water is described for treating steel panels, the panels being then rinsed in hot water, rinsed in chromic acid solution and baked at 600° F. (See Specification 483,551, of Patents Corporation.)

Alloys : Heat Treatment

In the manufacture of a corrosion-resistant clad aluminium alloy comprising a core of an aluminium alloy containing 2-5 per cent. of copper, 0.3-2.0 of magnesium, 0.2-1.5 of silicon and 0.2-1.5 of manganese, and of a facing of a similar aluminium alloy but containing no copper, the clad alloy is subjected to a solution heat treatment and quenching and then to artificial ageing within a temperature range from 130 to 230° C. until after an initial softening effect particularly high yield points are obtained. The amount of silicon in the alloys should exceed that required for the formation of the compound Mg_2Si. For an ageing temperature of 150° C. a suitable period of ageing is 3-10 days and for a temperature of 200° C. 2-6 hours, but if the alloy has been subjected to cold working prior to the heat treatment the periods of ageing may be reduced. (See Specification 485,292, W. H. A. Thiemann (Dürener Metallwerke Akt.-Ges.).)

Heat-Treating Metals

Granules of exfoliated vermiculite reinforced by a carbon coating are used as a heat insulating material in the heat treatment of metals, by surrounding the heated metal, *e.g.*, a hot ingot, immediately after stripping, with the material, whereby loss of heat is prevented, and, owing to the carbon coating, the metal is surrounded with a reducing atmosphere. Thus the material may be used in the steel industry for preventing oxidation and scaling of ingots in the soaking pits. The granules may be withdrawn from the soaking pit by a suction pipe. (See Specification 485,512 of British Zonolite Products, Ltd.)

Refining Metals and Alloys

Light metal melts are cleansed by treatment with pressed masses having a specific gravity exceeding that of the melt and comprising metallic lead and cleansing salts. The treatment is applicable to aluminium or its alloys, *e.g.*, aluminium-silicon alloys. The cleansing salts may comprise ammonium chloride, lithium chloride and cryolite. (See Specification 485,698 of Metallochemische Fabrik Akt.-Ges., and Claus, W.)

Coating with Metals

A metallic coating is produced on metal articles by applying to the surface a mixture of oxygen-containing metal compounds free from non-volatile reducing agents and capable of reduction at a temperature below 1,000° C. to form an alloy melting below this temperature, the coated article being then heated in a reducing atmosphere to form the molten alloy. The mixtures may be applied in the form of powder, or with suitable liquids as pastes, or with liquids such as volatile alcohols and esters in the form of "paints." The mixtures of compounds described in Specification 483,156, may be employed, in which may be incorporated oxides of gold or of metals of the platinum group, or the metals themselves in finely-divided precipitated form, as for example with mixtures of two or more of the oxides of silver, copper, tin, zinc, or cadmium, to produce coatings of precious metal alloys for inexpensive jewellery. Tubes or other hollow articles may be coated internally by the process. (See Specification 485,977 of P. W. Noble and A. R. Powell).

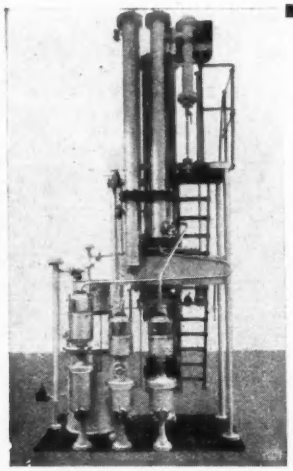
Alloys : Tempering

High mechanical strength and electrical conductivity are produced in copper-tin alloys containing 3-16 per cent. of tin by cold forging, rolling or drawing with at least a 10 per cent. reduction in thickness for an alloy containing 16 per cent. of tin and 80 per cent. for a 3 per cent. tin alloy, and then tempering at 150-350° C. for at least an hour and for a time longer than that required for the production of the desired conductivity. The cold-working and tempering may be repeated. The alloys may also contain one or more of silicon, aluminium, iron, phosphorus, nickel, zinc and magnesium up to a total amount of 2 per cent., the minimum tin content then being reduced to 1 per cent. (See Specification 486,600 of British Thomson-Houston Co., Ltd.).

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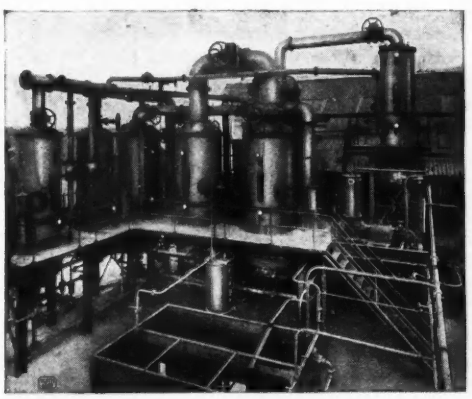


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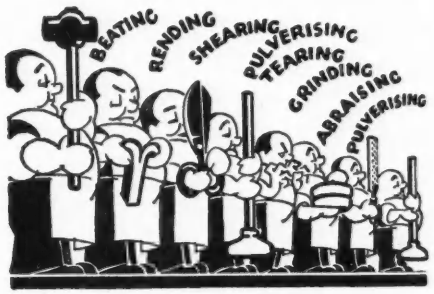
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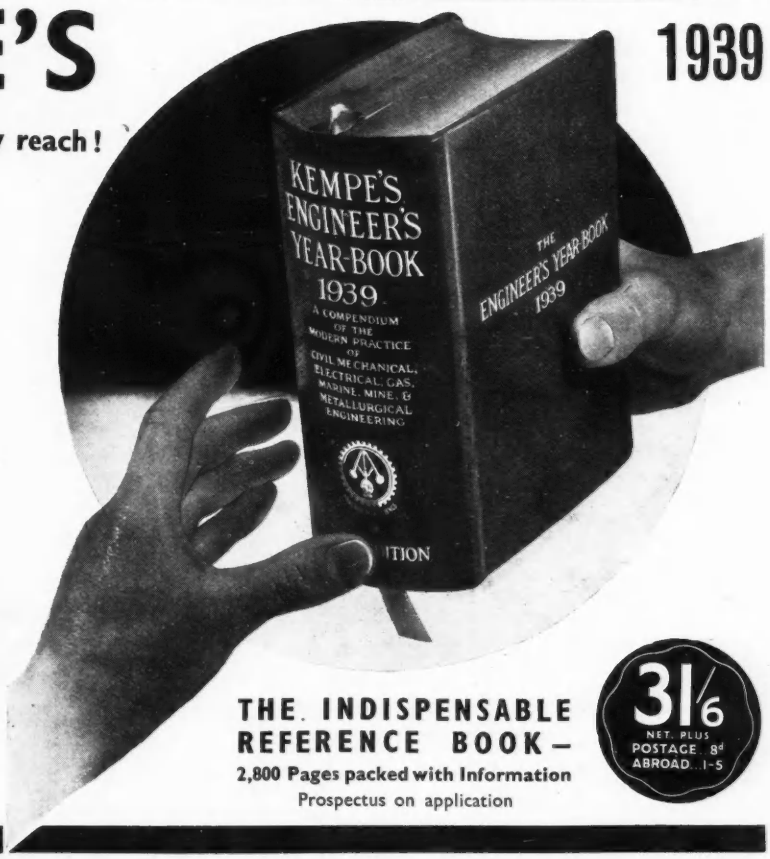
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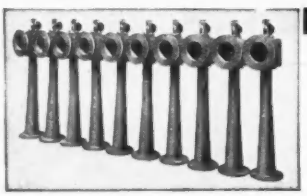
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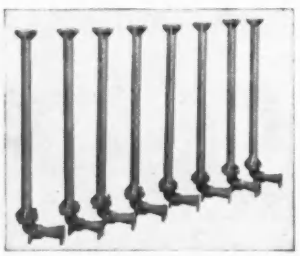
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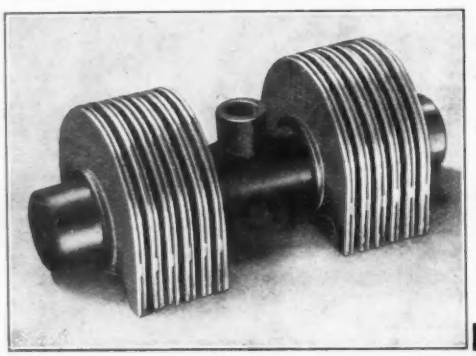
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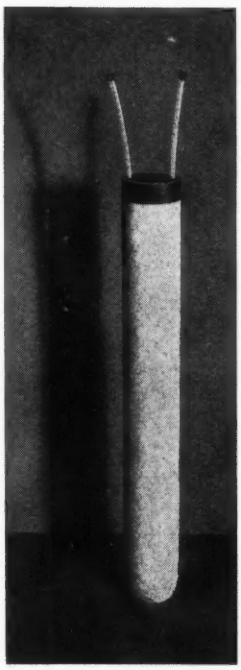
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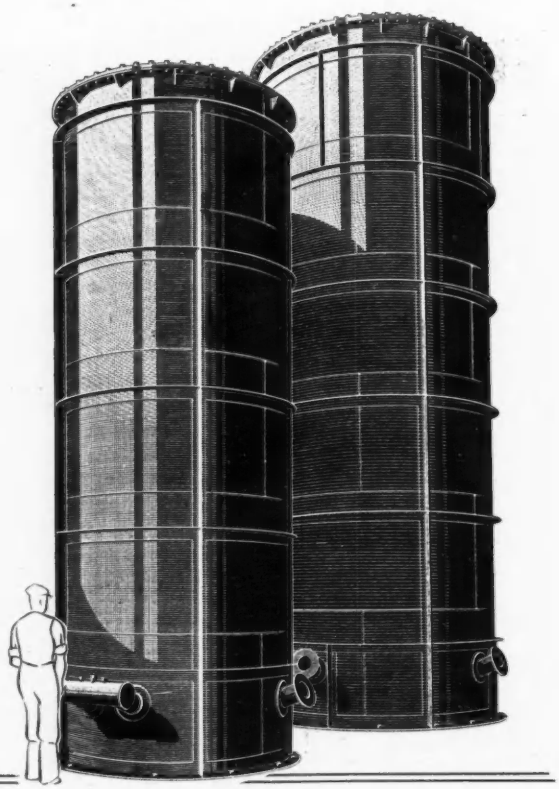
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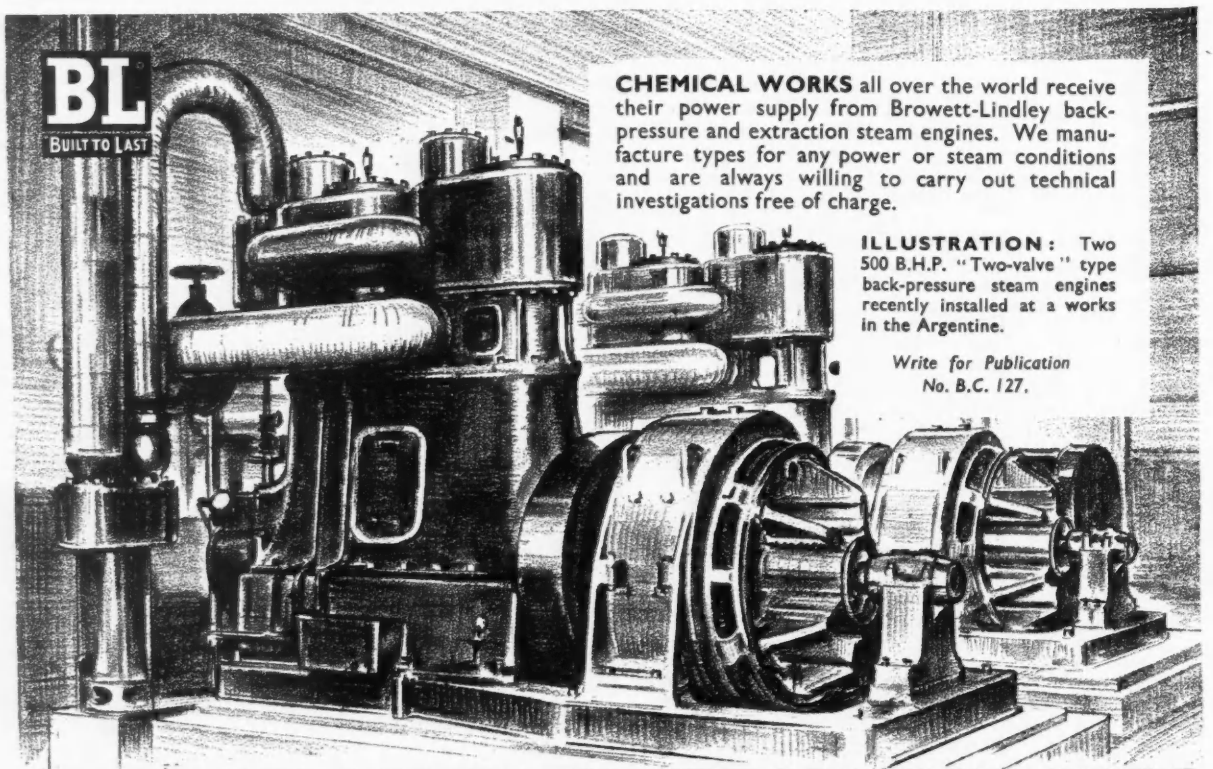
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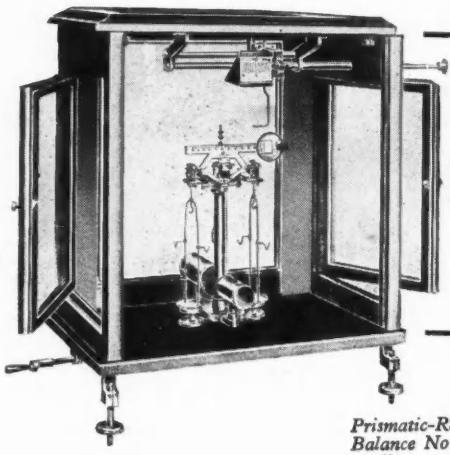
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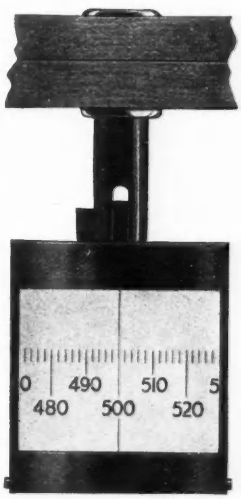
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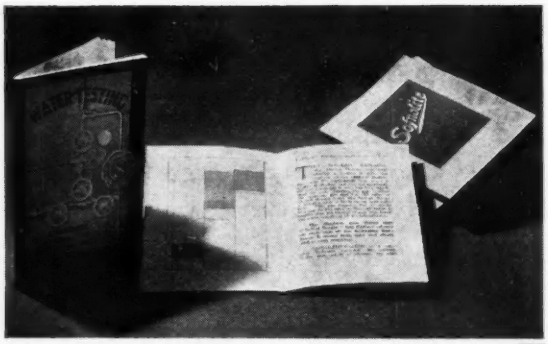
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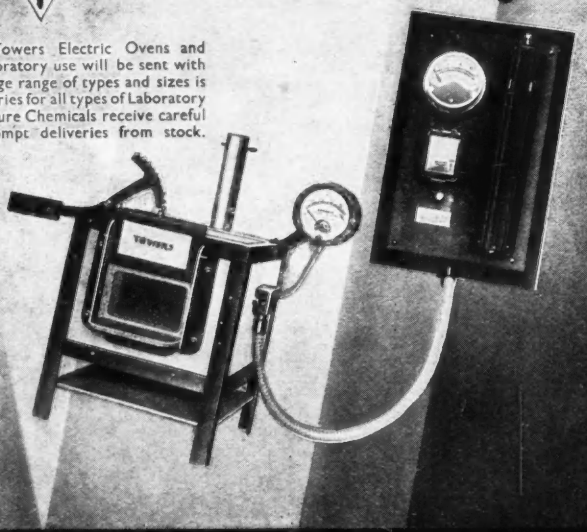

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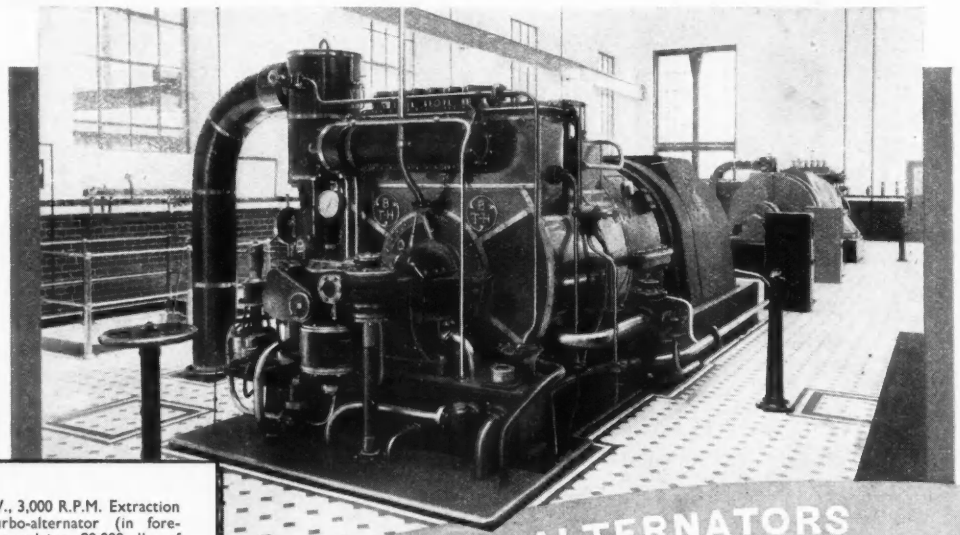
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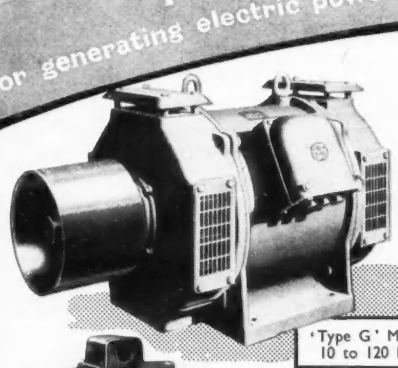
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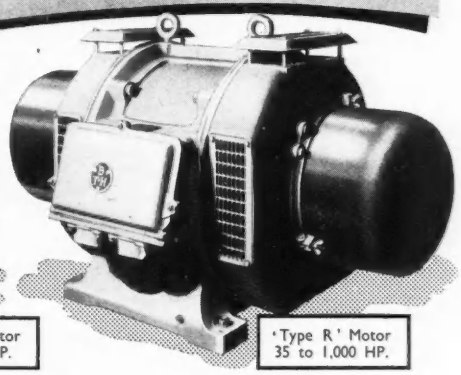
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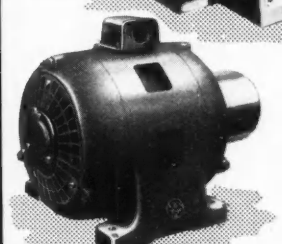
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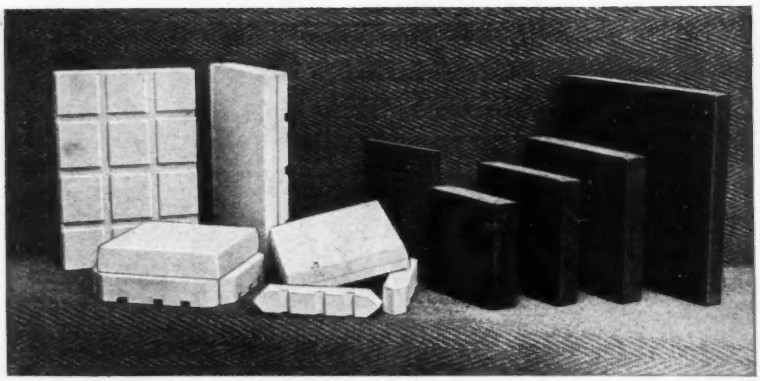
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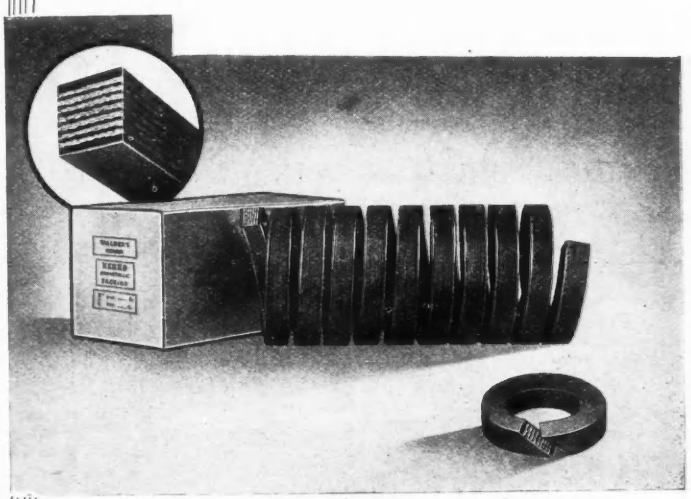
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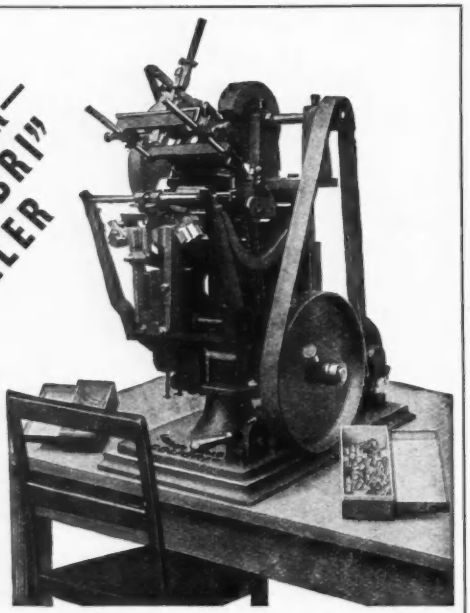
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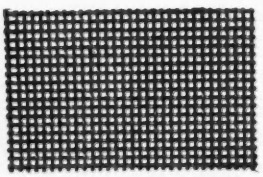
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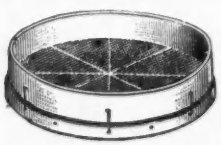
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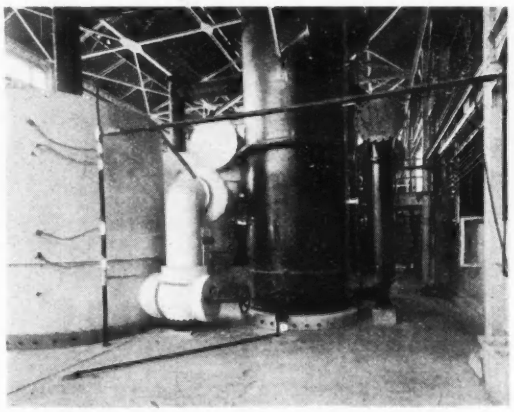
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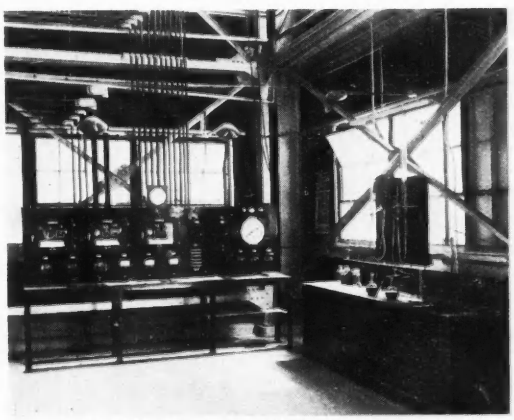
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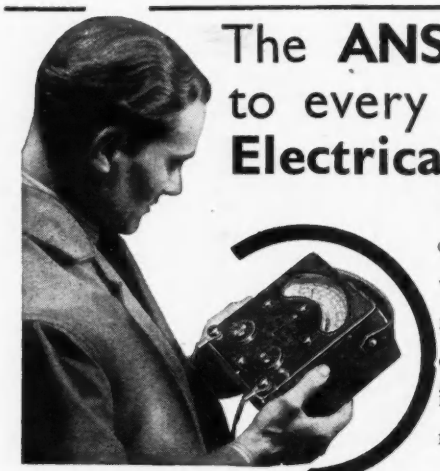
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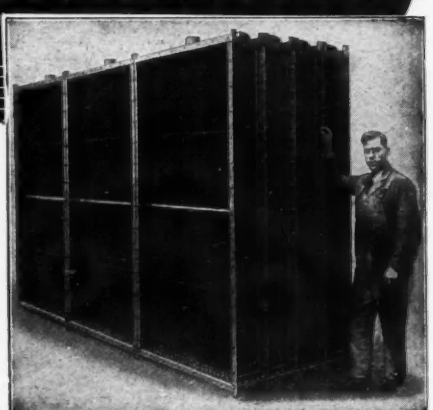
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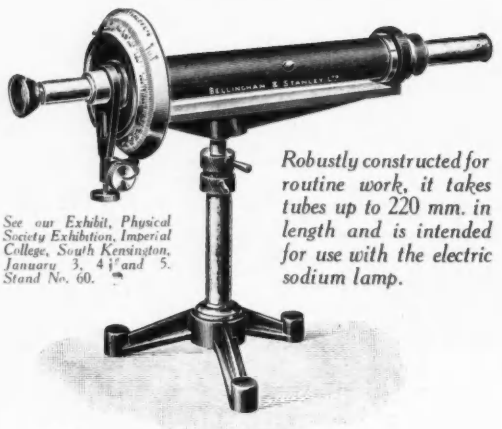
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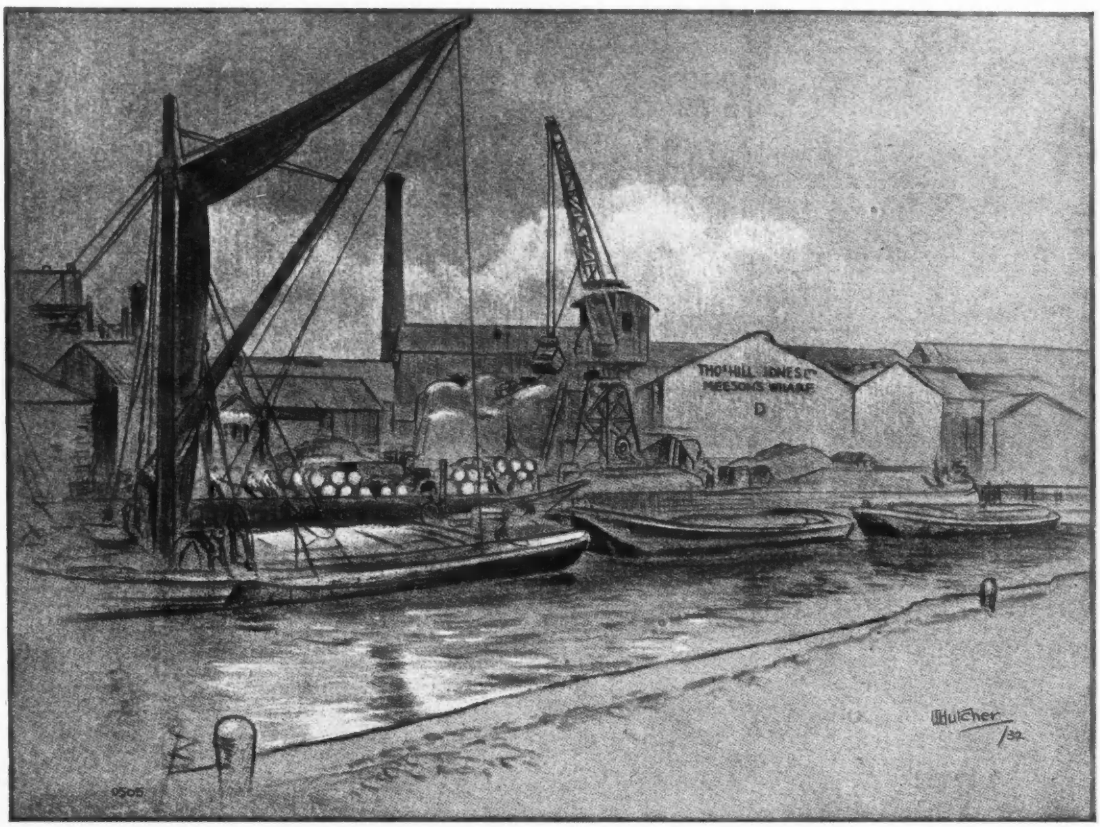
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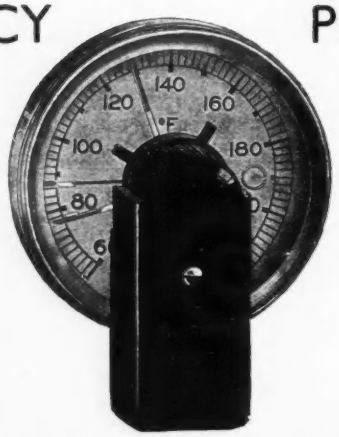
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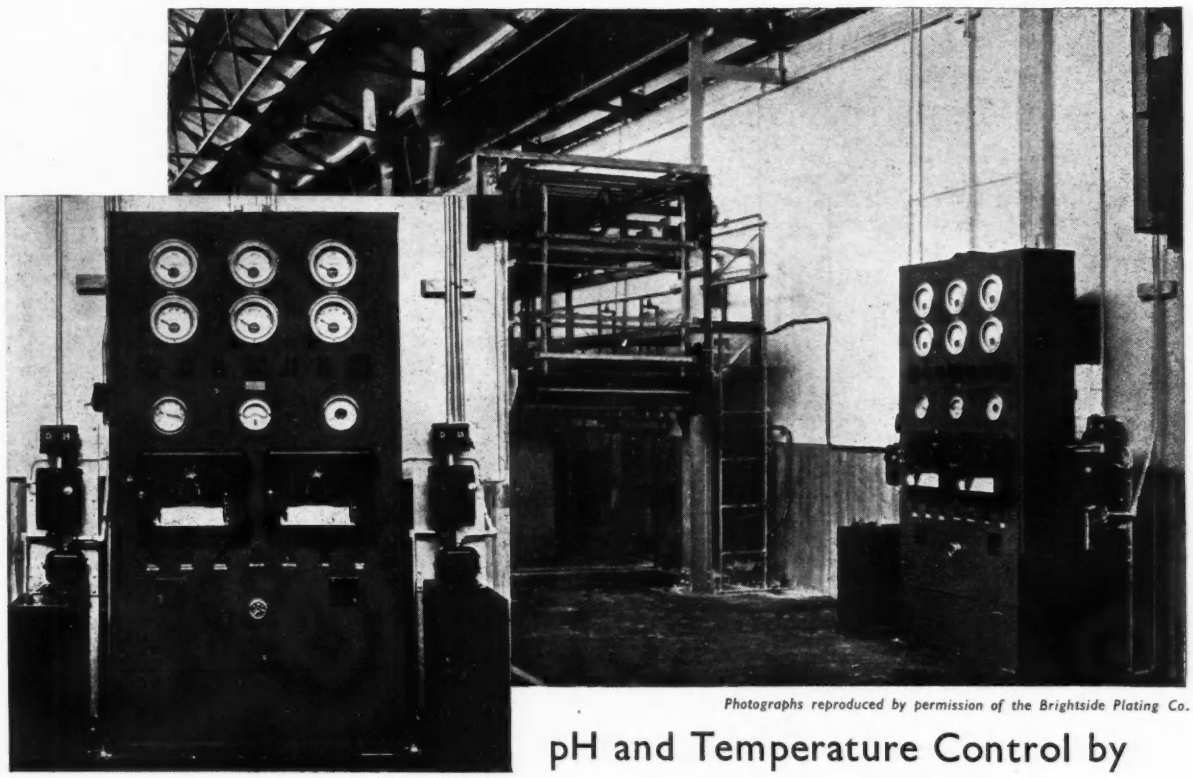
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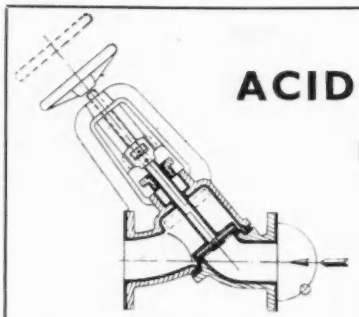
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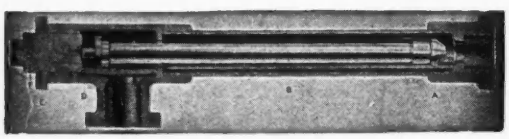
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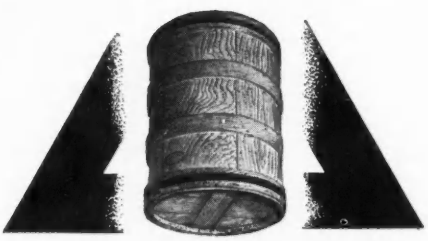
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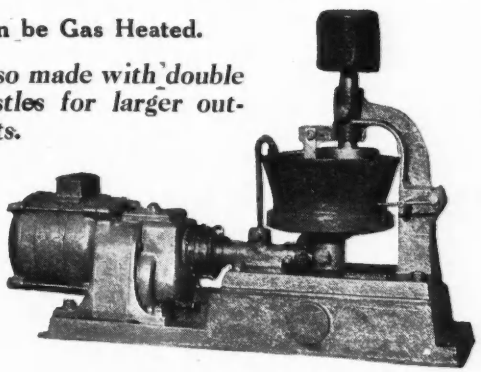
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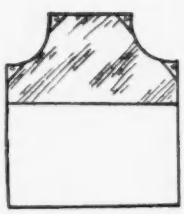
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Specialists in Head to Foot Protective Measures

SECURITY and COMFORT for the WORKER ensures increased PRODUCTION